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POWER AND THE ENGINEER

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Vol. 29. Index to Advertisers and Classified Index Following Reading Matter No. 22.

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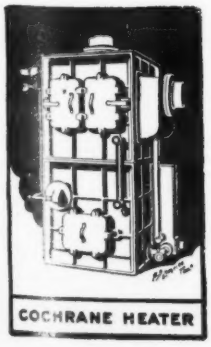

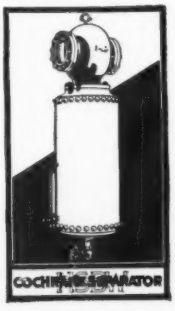

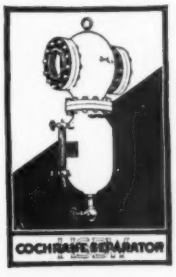

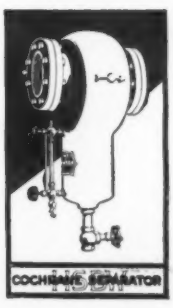

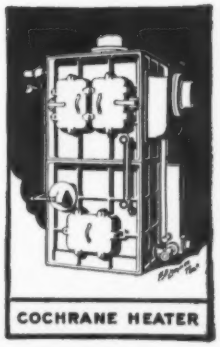

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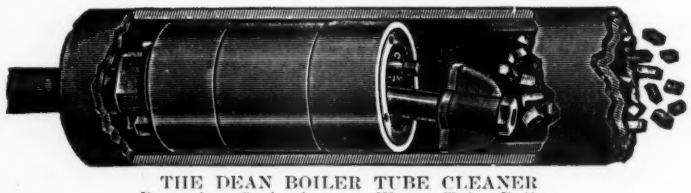

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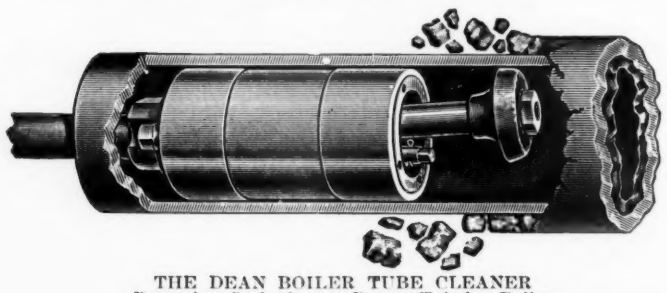

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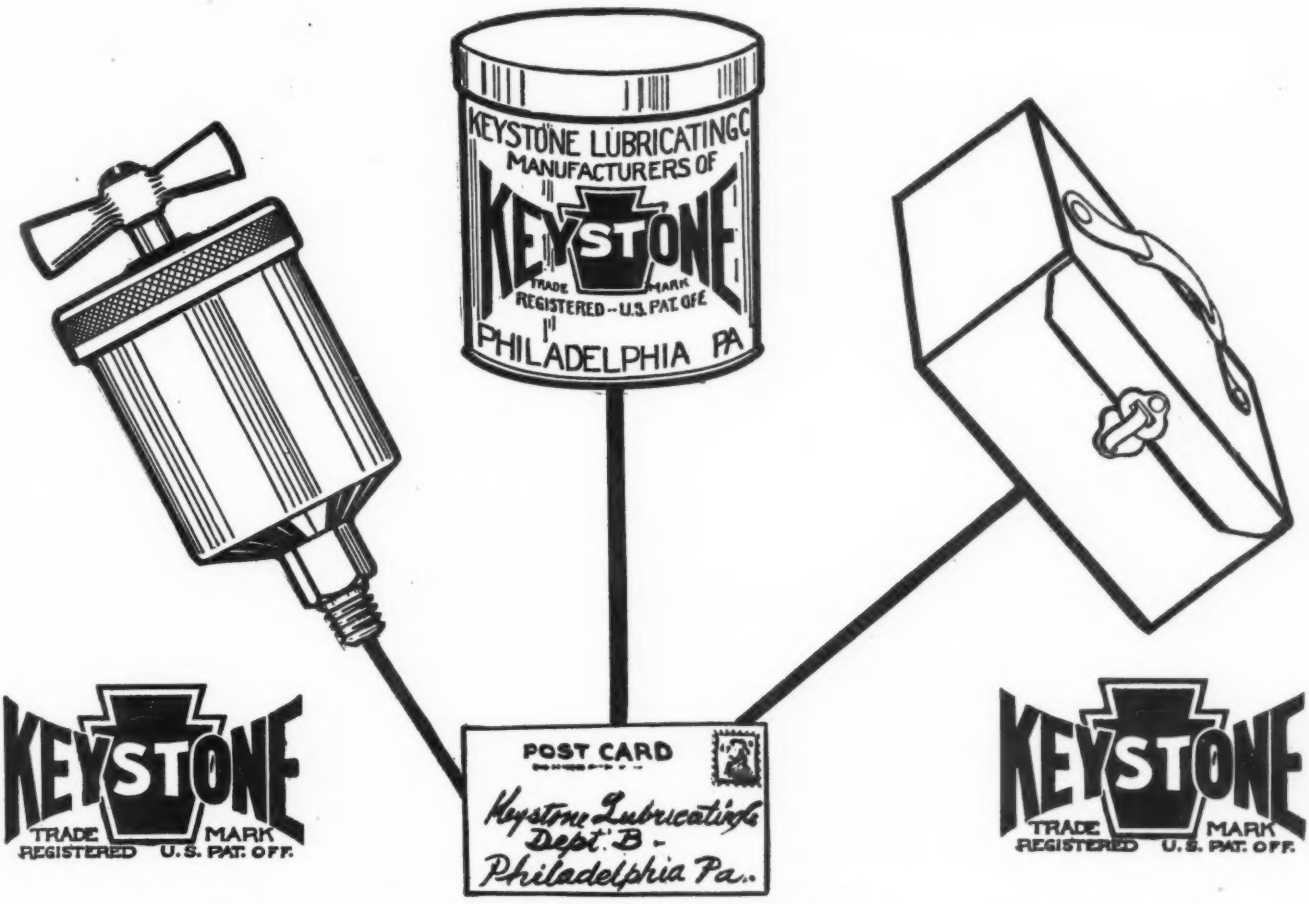

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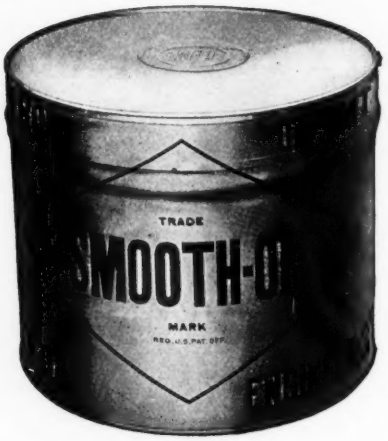

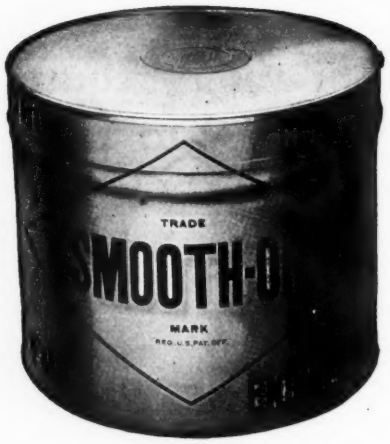

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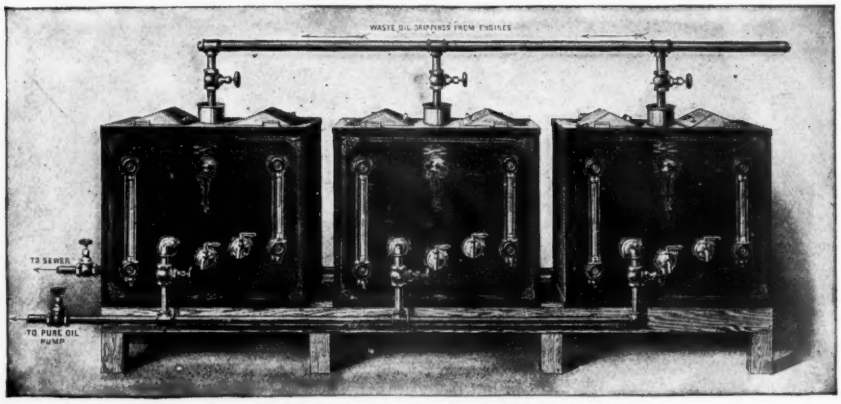

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Setting the Valves of a Russell Engine

Thorough Study of Complete Valve Movement of Four-valve Engine with Meyer Cutoff and Separate Exhaust Valves of Rotative Type

BY HUBERT E. COLLINS

The Russell four-valve engine is illustrated in the accompanying photographs. Fig. 1 is a front view and Fig. 2 the rear or valve-gear side. The steam chest is shown at *A*, Fig. 2, in which are located the main steam and cutoff valves. The two exhaust valves are at *B* and *C*, Fig. 2, and their back bonnets may be seen at *B* and *C*, in Fig. 1. The cutoff eccentric rod is shown at *D*, Fig. 2, and the main eccentric rod, which drives the main steam and exhaust valves, is immediately behind the cutoff rod. The main eccentric rod is to be seen at *D*, Fig. 1. The main rocker arm *E*, Fig. 2, transmits the eccentric motion direct to the main steam valve and indirectly turns the exhaust valves. The cutoff rocker *F* transmits the cutoff or governor-eccentric motion direct to the cutoff valve. It will be apparent that this valve gear is of a design unlike any other on the market. The admission is controlled by the main steam valve and the cutoff by the cutoff valve, while exhaust release and compression are regulated on each end separately by the exhaust valves.

A further understanding of the design and arrangement of these valves may be had by reference to Figs. 3 and 4, the former being a horizontal section through the cylinder and valve chest, and the latter a vertical section through the steam chest, showing the steam valves in place and a cross-section of the exhaust valves and ports. In both figures the same letters designate the same part. The main steam valve is shown at *A* and the cutoff at *B* riding over the main valve; *V V* are the exhaust valves, *D D* the steam ports on the side and *E E* the exhaust ports on the bottom of the cylinder; *F F* are the exhaust-valve plugs which are removable with the valves; *G G* are the connecting bolts which hold the two ends of the main valve together and *H H* are the cutoff-valve bolts. The main valve stem, represented by *I*, connects the valve *A* to the rocker *E* of Fig. 2, while the cutoff-valve rod *K* connects the cutoff valve to the rocker *F* of Fig. 2. The exhause wristplate *L* is connected to the two exhaust valves by the rods *M M* and to the main rocker *E* of Fig. 2 by the reach rod *N*. The steam passes the throttle into the steam chest *P*, and after leaving the cylinder passes into the exhaust chamber *Q* underneath. The plates *S S*, in conjunction with the springs shown, prevent the valves from slamming.

Eccentric Positions in Relation to Crank

The position of the main and cutoff eccentrics in relation to the crank and governor, and the relative position of the governor wheel on the shaft are shown in Fig. 5. The crank pin is at the point marked *A*, the main eccentric at *B*, the position of the cutoff eccentric while giving maximum cutoff is at *C*, and while giving minimum cutoff at *D*. While the cutoff eccentric is at the point of maximum cutoff, the governor parts are in the positions shown by the full lines, and the dotted lines show positions for minimum cutoff. In its operation the governor-cutoff eccentric has a range of 110 degrees.

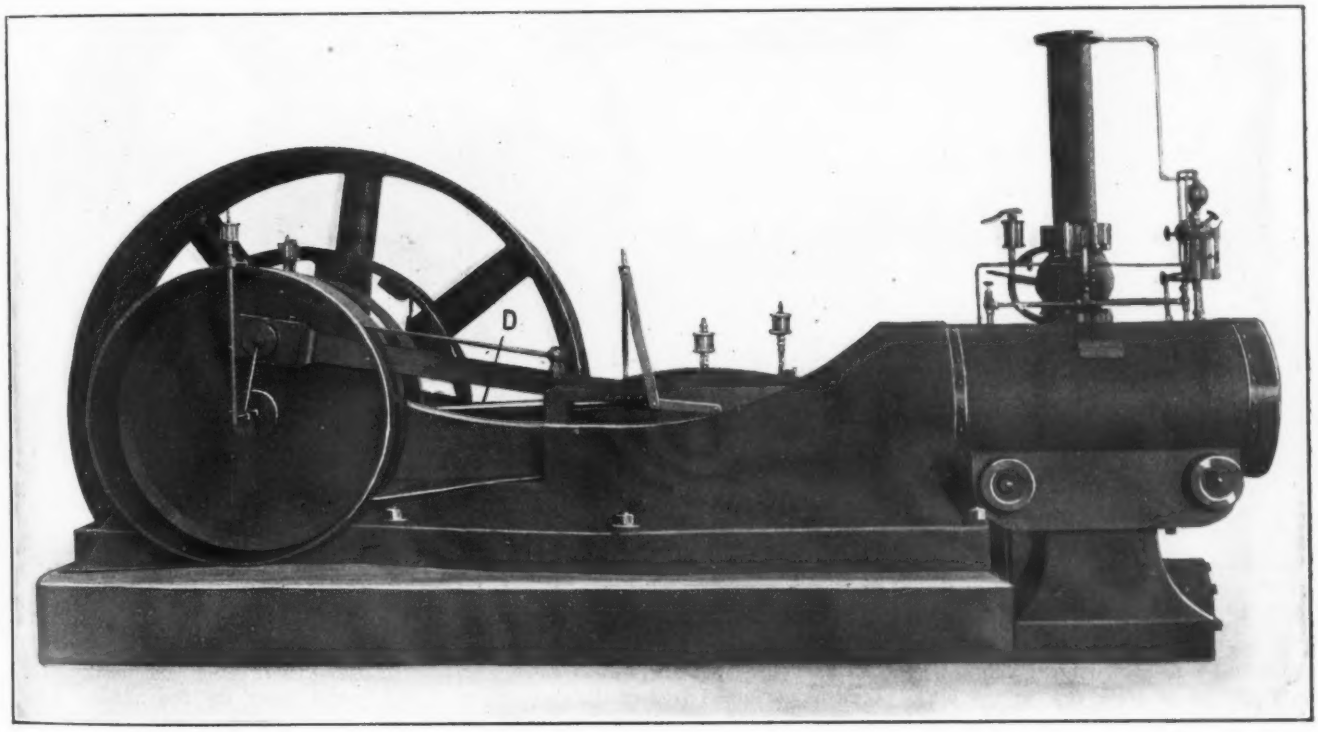


FIG. 1. FRONT VIEW OF RUSSELL ENGINE

Valves and Valve Movement

The exact arrangement of the steam and exhaust valves in the cylinder of one of these engines is shown in Figs. 3 and 4, but in order that the relative movements of the four valves may be studied to better advantage during one revolution of the crank, the main steam and cutoff valves, from Fig. 6 on, are shown in cross-section above the exhaust just as if they were situated on top of the cylinder. With this arrangement of illustrations it is easier to get an idea of the direction of motion and positions at different points of the stroke will be obtained. In Figs. 6 to 13, inclusive, the same reference letters refer to the same part, so that an explanation of one figure will cover them all.

Fig. 6 shows the main steam valve *A A* and the cutoff *B B* situated over the steam ports *D D* in the upper half, and the exhaust wristplate *W*, the valves *V V* and the exhaust ports *E E* in the plugs *F F* in the lower half. The circles *H* and *C* are the head- and crank-end eccentric circles, respectively, which are shown for convenience in locating the positions of crank and eccentrics at any time. The crank is indicated by *X*, the main eccentric by *M* and the cutoff eccentric by *C O*. The valves are all shown in their central position in which the main steam and exhaust valves show lap. The main eccentric operates the main steam valve direct, so that the position of the main eccentric *X* on the circle indicates the relative position of the main valve, and as the same eccentric operates the exhaust valves reciprocating from the same rocker arm the position of the exhaust movement is directly opposite to that of the main steam valve. In this figure the exhaust is at point *R* on the eccentric circles.

As the main steam valve controls the steam admission only, it is shown lapped at *G G* the usual amount and at *P P* sufficient to cover the ports at all times. It will be noted that with all the valves in a central position, as in Fig. 6, the outside edges *K K* of the cutoff valve overlap the steam ports *L L* at the ends of the main valve, leaving an effective opening which equals in area the other ports *L* in the main valve. The steam is at first admitted through the three openings at the end of the main valve into the main port before it enters the cylinder port *D*. The two inside ports on each end of the main valve are negatively lapped by the cutoff to such an extent that when the outside port is wide open they are closed, and when the two inside ports are just full open the end port is open enough so that the combined area of the three ports equals that of port *D*. It will also be noted that the widest port in the main valve does not equal port *D* in width. These points will be brought out more clearly in subsequent figures.

In the lower half of Fig. 6 the wristplate *W*, which operates the exhaust valves, is shown with the hook-rod pin at *N*. The two valve rods *O O*, together with the center lines of the valve cranks, are shown in full, while the dotted lines show the two extreme positions of these parts. The dotted curves show the respective paths of travel of each pin. The exhaust valves are shown lapped, and the two arrows show the direction of travel while the valves open.

With the crank on its center, and the engine to turn in the direction of the arrows at the eccentric circles, we will proceed to set the main eccentric ahead to the position it should occupy to give lead, leaving the cutoff eccentric still in its central position. The condition would then be as shown in Fig. 7, where only the steam valves are shown. It can thus be seen that the cutoff valve closes the ports of the main valve on the crank end, so that the lead of the main valve would be of no service. The cutoff eccentric is then advanced to the position shown in Fig. 5 and also in Fig. 8, where the position of all the valves is shown when the engine is ready to start from the crank center. Noting the position of the main and cutoff valves in Fig. 8, it will be seen that the two are still traveling in the same direction, and if they were traveling at the same rate of speed there would be only one port (the end port of the main valve) open for the admission of steam on the crank end. But by referring to the eccentric circles it will be seen that the main valve is traveling faster and will overtake the cutoff valve before it reaches the extreme of its travel, opening up the ports *L L* along the edges *K K* enough to make the total port area equal the total area of the large port of the main valve. This can be easily understood by referring again to the crank-end eccentric circle, where it can be seen that while the cutoff eccentric moves from point *1* to *2*, the cutoff valve has moved only the distance *3*; at the same time the main eccentric has moved a distance equal to that of the cutoff eccentric, or from point *4* to *5*, but the main valve has moved the distance *6*, or nearly three

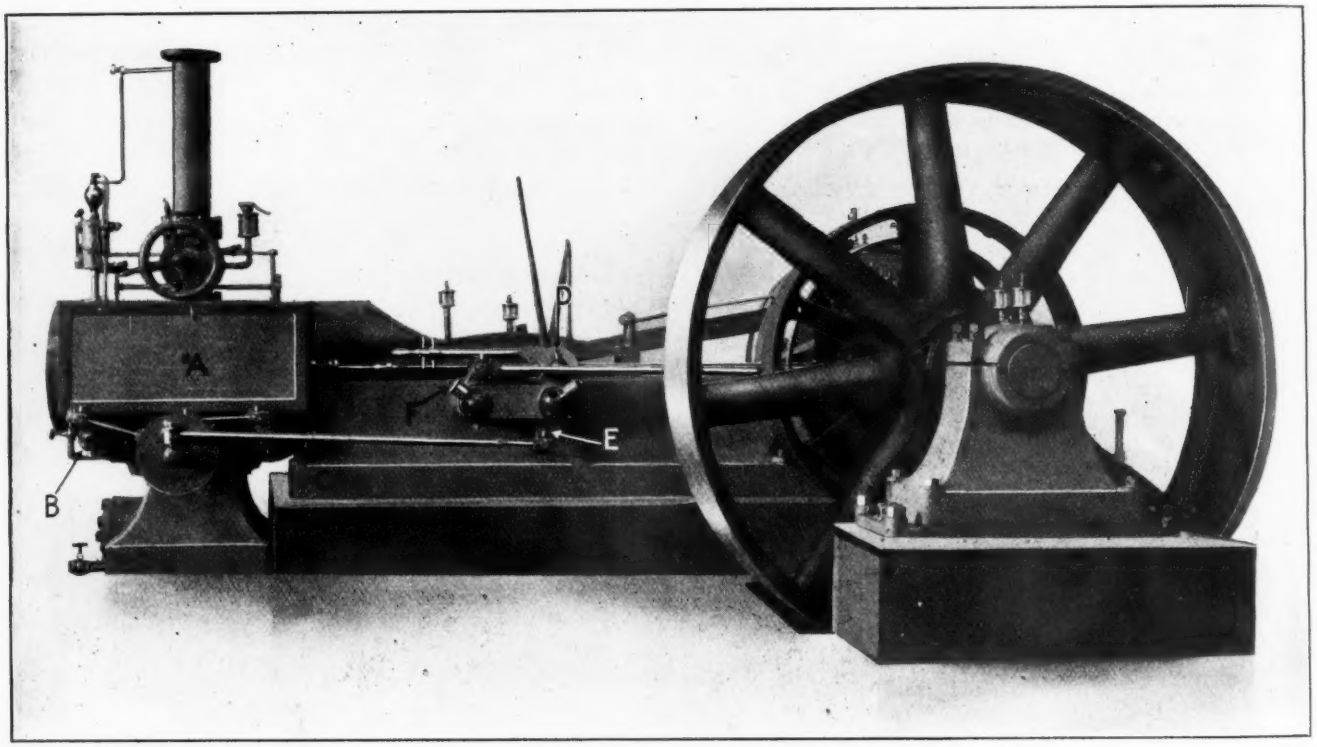


FIG. 2. VALVE-GEAR SIDE OF RUSSELL ENGINE

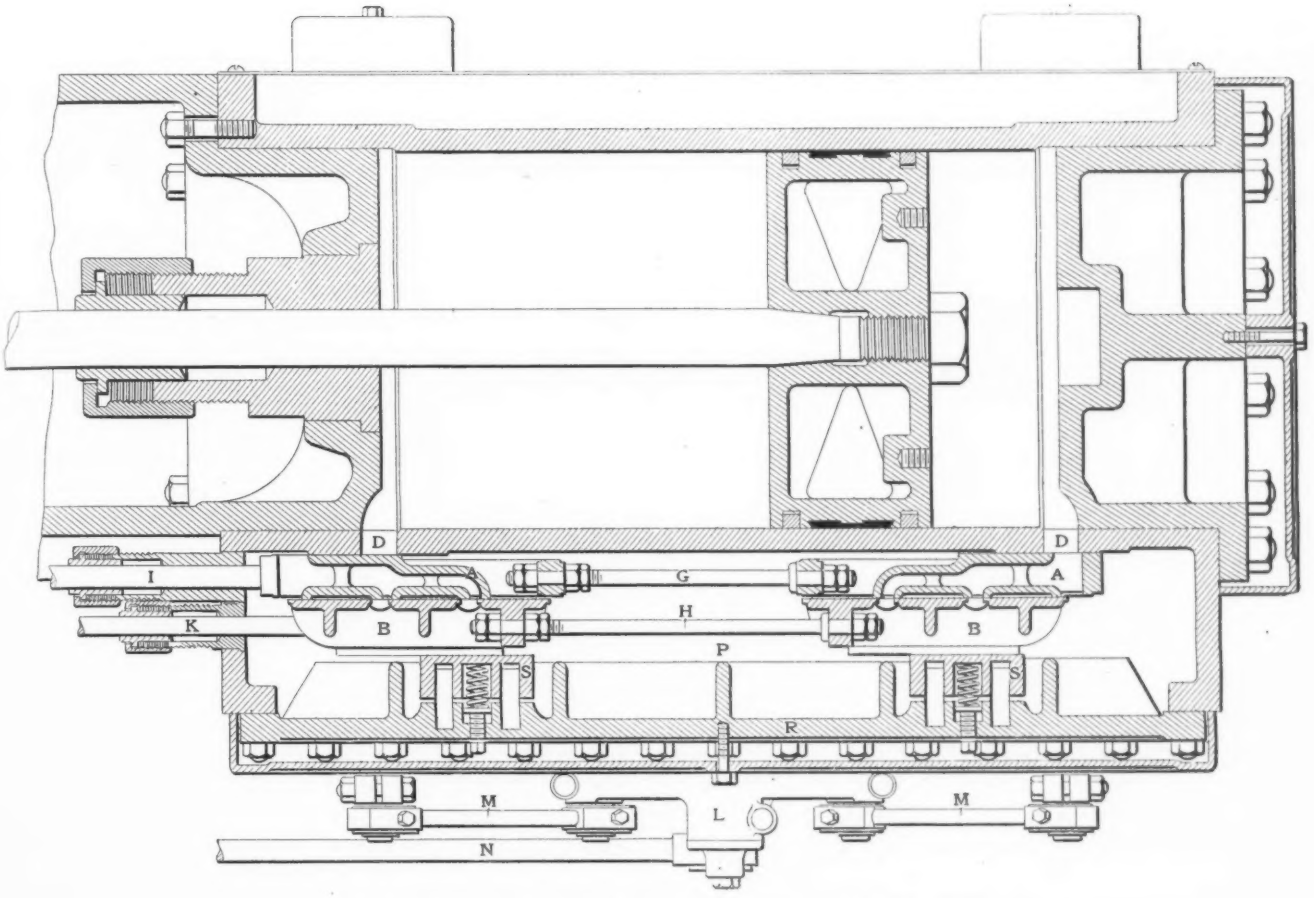


FIG. 3. HORIZONTAL SECTION THROUGH CYLINDER AND VALVE CHEST

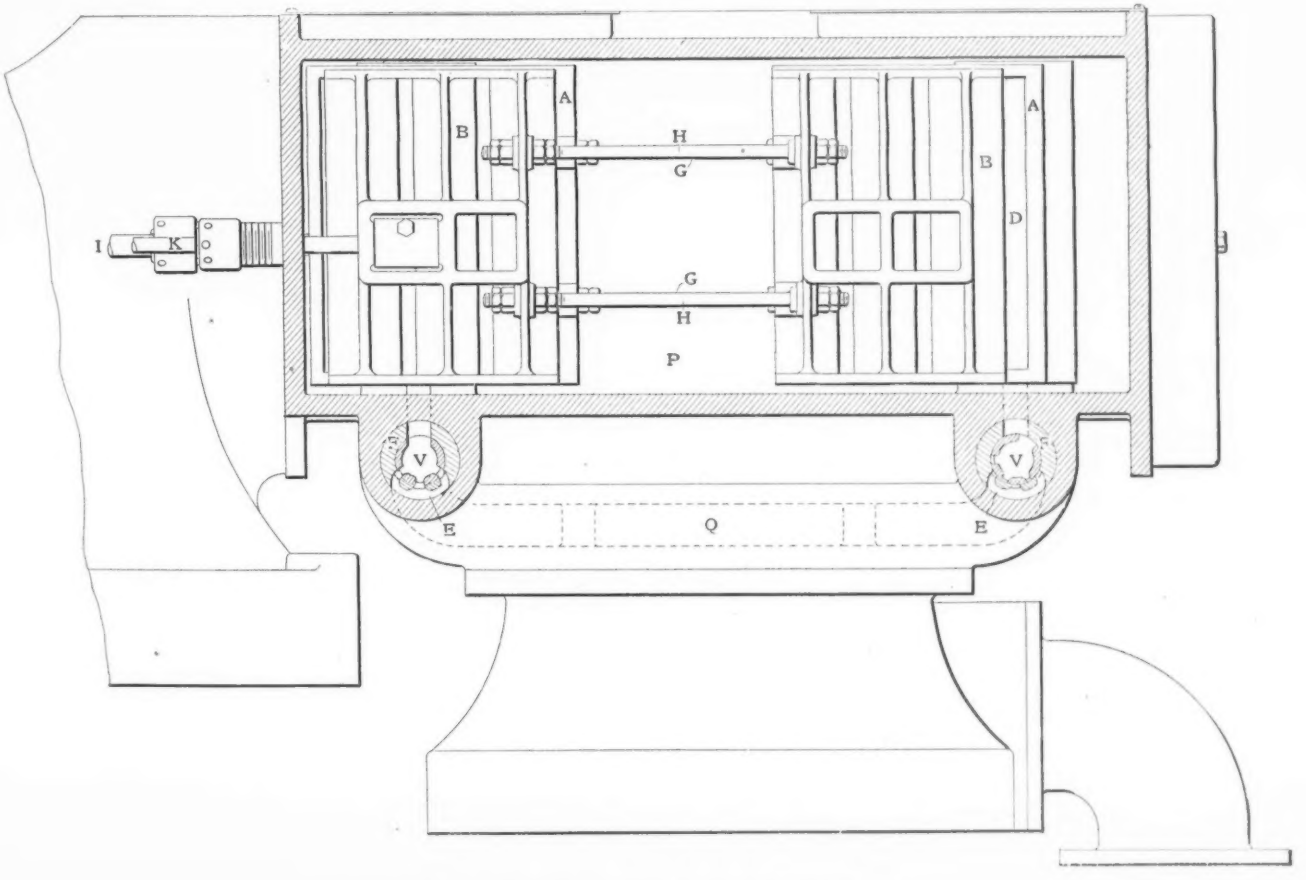


FIG. 4. VERTICAL SECTION THROUGH VALVE CHEST

times as much as the cutoff. As shown in Fig. 8, the edges *K K* are line and line with the port edges, but when the eccentrics had moved the distances indicated, the two valves would be admitting steam through the three ports.

Having noted the position of the steam valves in Fig. 8, it will also be seen that the head-end exhaust valve has opened to a considerable extent, while the crank end has closed a like amount. The wrist-plate is traveling in a direction opposite to the main eccentric, and the exhaust valves in the direction of the arrows. In Fig. 9 the point of cutoff has been reached, the two steam valves traveling toward the left of the diagram. It will be noted that the cutoff valve has traveled faster than the main steam valve, overtaking it and cutting off the steam on the crank end as shown. The cutoff valve travels fastest here, for the reason that the cutoff eccentric first enters the area of travel which transmits the fastest motion to the valve.

For the same reason that the main valve was traveling fastest in Fig. 8, it is traveling slowest in Fig. 9. The maximum point of cutoff in these engines is about 75 per cent. It will be noted that the head-end exhaust valve has begun to travel in the direction to close the ports and the crank end is traveling in the direction to open the valve. Fig. 10 shows the positions when the crank-end exhaust valve has reached the point of release.

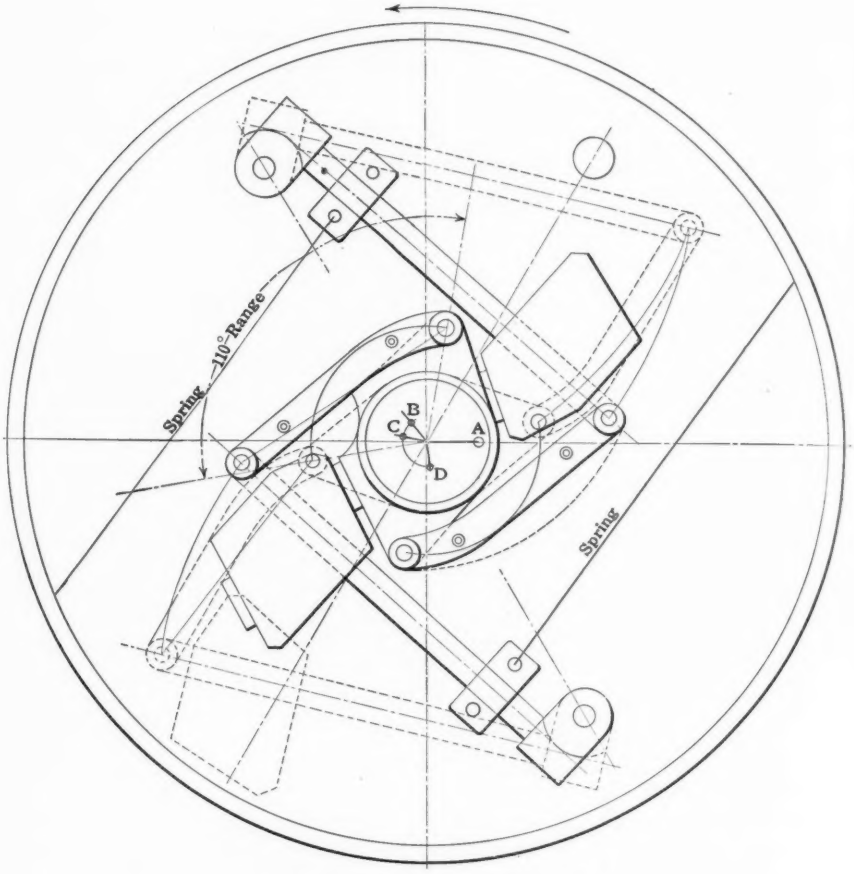


FIG. 5. THE GOVERNOR IN OUTLINE

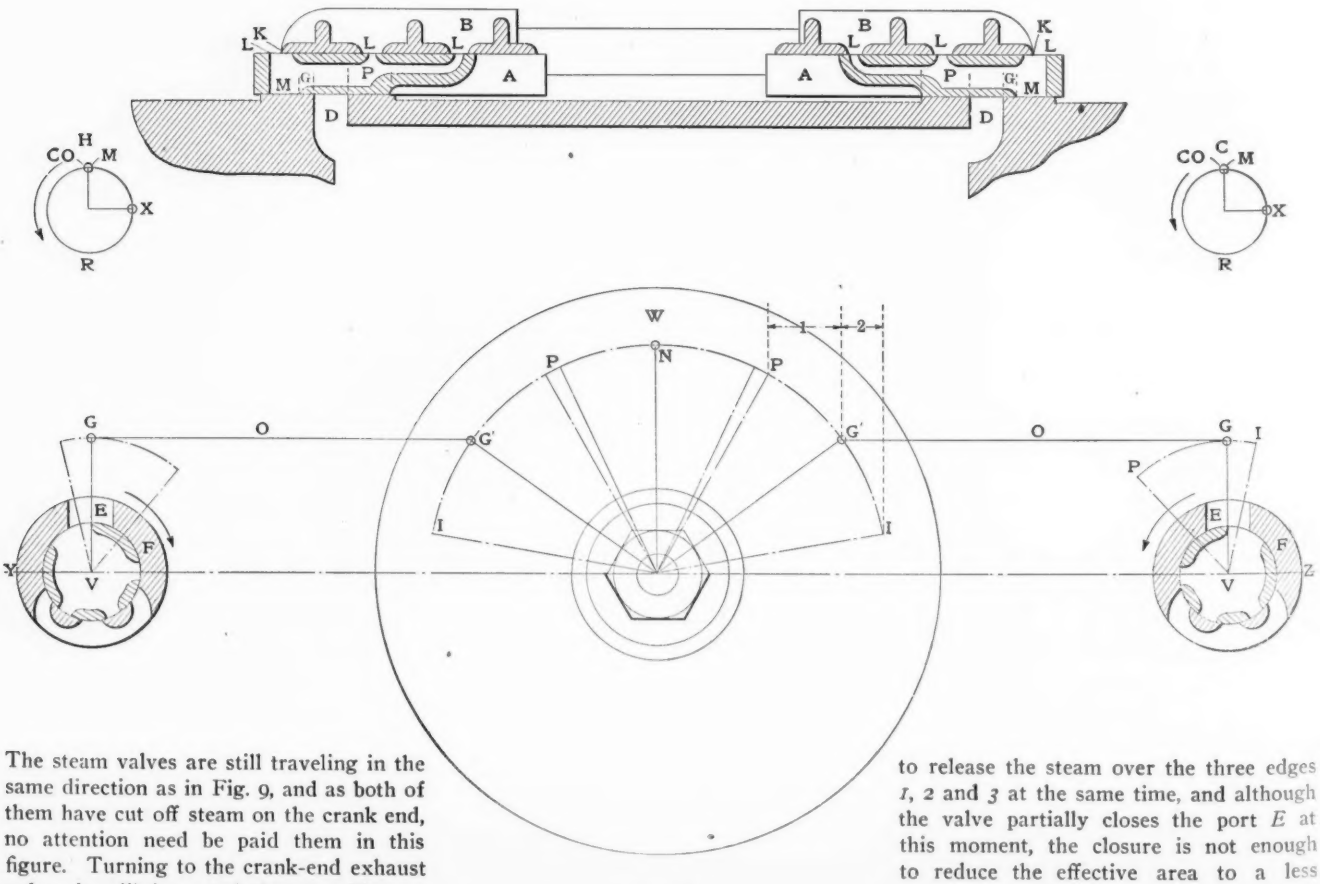


FIG. 6

The steam valves are still traveling in the same direction as in Fig. 9, and as both of them have cut off steam on the crank end, no attention need be paid them in this figure. Turning to the crank-end exhaust valve, it will be noted that it will start to release the steam over the three edges *1*, *2* and *3* at the same time, and although the valve partially closes the port *E* at this moment, the closure is not enough to reduce the effective area to a less amount than the area uncovered by the

edges *1*, *2* and *3*, and as the area increases at one place, so it does at the other. The head-end exhaust valve has closed before the other has reached the point of release. Figs. 11, 12 and 13 show the positions of all the valves for lead, cutoff and release on the head end, after which the crank will have arrived at the position shown in Fig. 8 and completed one revolution.

The exhaust-valve action is fastest while releasing and closing. This can be clearly understood by referring again to Fig. 6, where the wristplate is on the center of its throw. In this illustration the center of the wristplate is on the same line *Y Z* as the center of the exhaust valves, and so long as the valve-rod pins *G G* travel above this center line, they will cause the exhaust valve to travel with the greatest speed when the pin moves from *G* to *P*, and slowest when traveling from *G* to *I*. In this instance we have selected the crank end for illustration. When the two pins *G'* at each end of the rod *O* move to the points *P*, we get the distance *1*, and when they move to *I*, we get the distance *2*. While the pins are moving the distance *1*, the valve is either opening or closing and is traveling fast, and when the pins are moving the distance *2* and back, the valve remains lapped.

Essential Features of the Valves

The essential features of this arrangement of the four valves brought out in this study are principally:

1. The main valve controls admission alone, always covering the port after cutoff until it opens for lead.

2. The cutoff valve controls the point of cutoff and is controlled by the governor.

3. The exhaust valves rotate and are of such design as are used on Corliss engines, being triple-ported.

4. The main steam and exhaust valves are operated by the one main eccentric on the shaft.

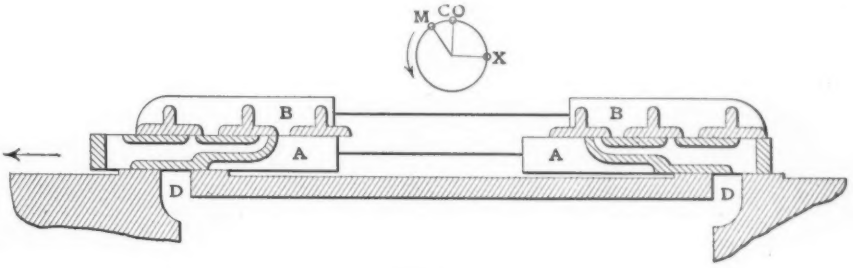


FIG. 7

5. The main eccentric is advanced as usual to overcome lap and lead, and the cutoff eccentric is ahead of the crank about 170 degrees when giving maximum cutoff, following the crank about 80 degrees when giving minimum cutoff.

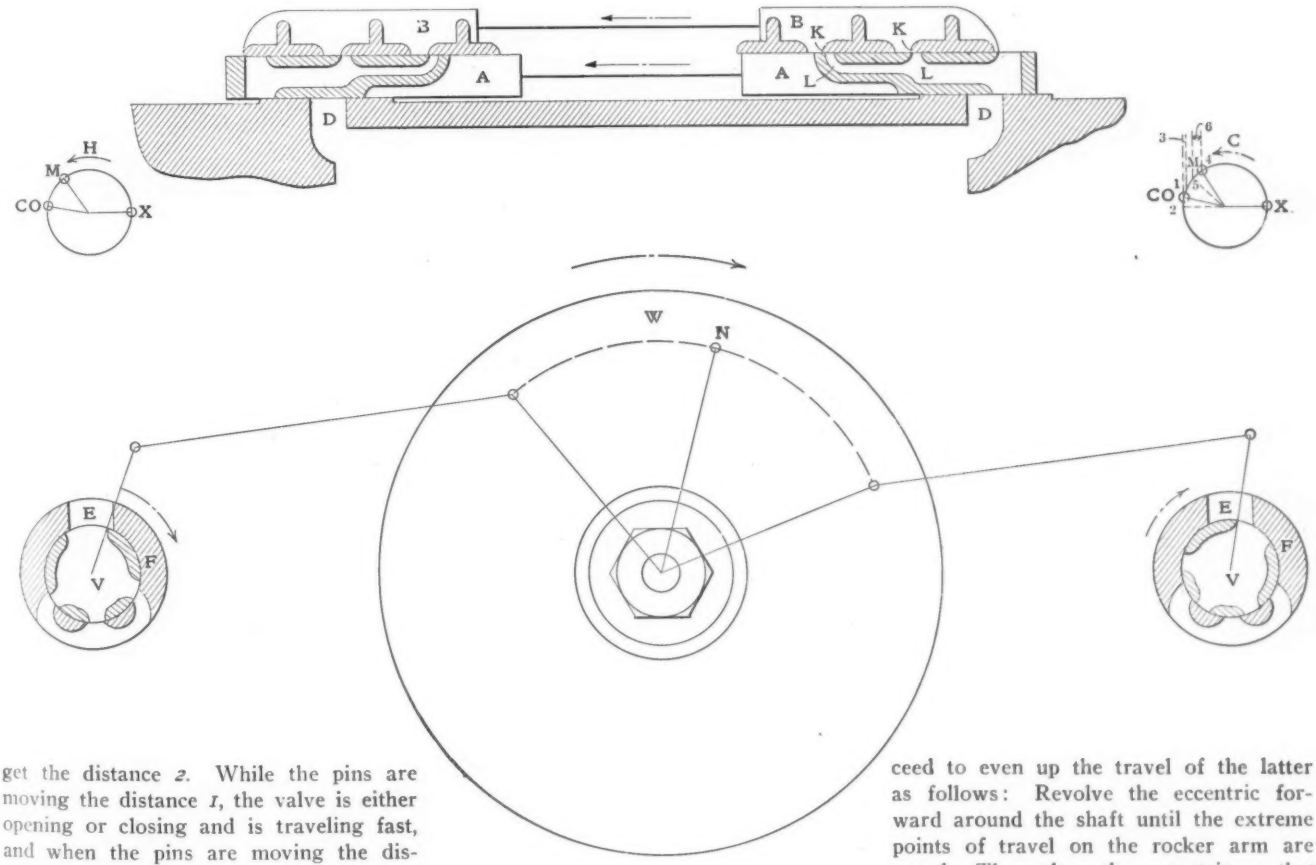


FIG. 8

When the lap of a single-ported main valve is 25 per cent. of the travel, the cutoff eccentric follows the crank to give the maximum cutoff and is ahead of the crank when giving minimum cutoff. The positions of the eccentric are reversed when the lap of the main valve is less than 25 per cent. of the travel, as in this case.

Setting the Valves

These instructions are given with the assumption that there are no shop marks to go by. It may be explained that the eccentrics of these engines are made in halves, so that they may be removed after the engine is assembled.

First, place the main eccentric on the shaft with its strap in place and connect the eccentric to the top end of the rocker arm. The main eccentric should be so placed latterly on the shaft as to come close up to the main bearing. After connecting the eccentric to the rocker, proceed to even up the travel of the latter as follows: Revolve the eccentric forward around the shaft until the extreme points of travel on the rocker arm are noted. Then place the eccentric so that the rocker is in the center of its travel. If the rocker arm is not perpendicular when on its center, loosen the sheath nut at the eccentric end of the rod and either shorten or lengthen it to bring the rocker arm exactly upright. When this position of the rocker arm is correct, and while it is still central, fasten the eccentric so as to hold it there and proceed to connect the reach rod from the lower end of the

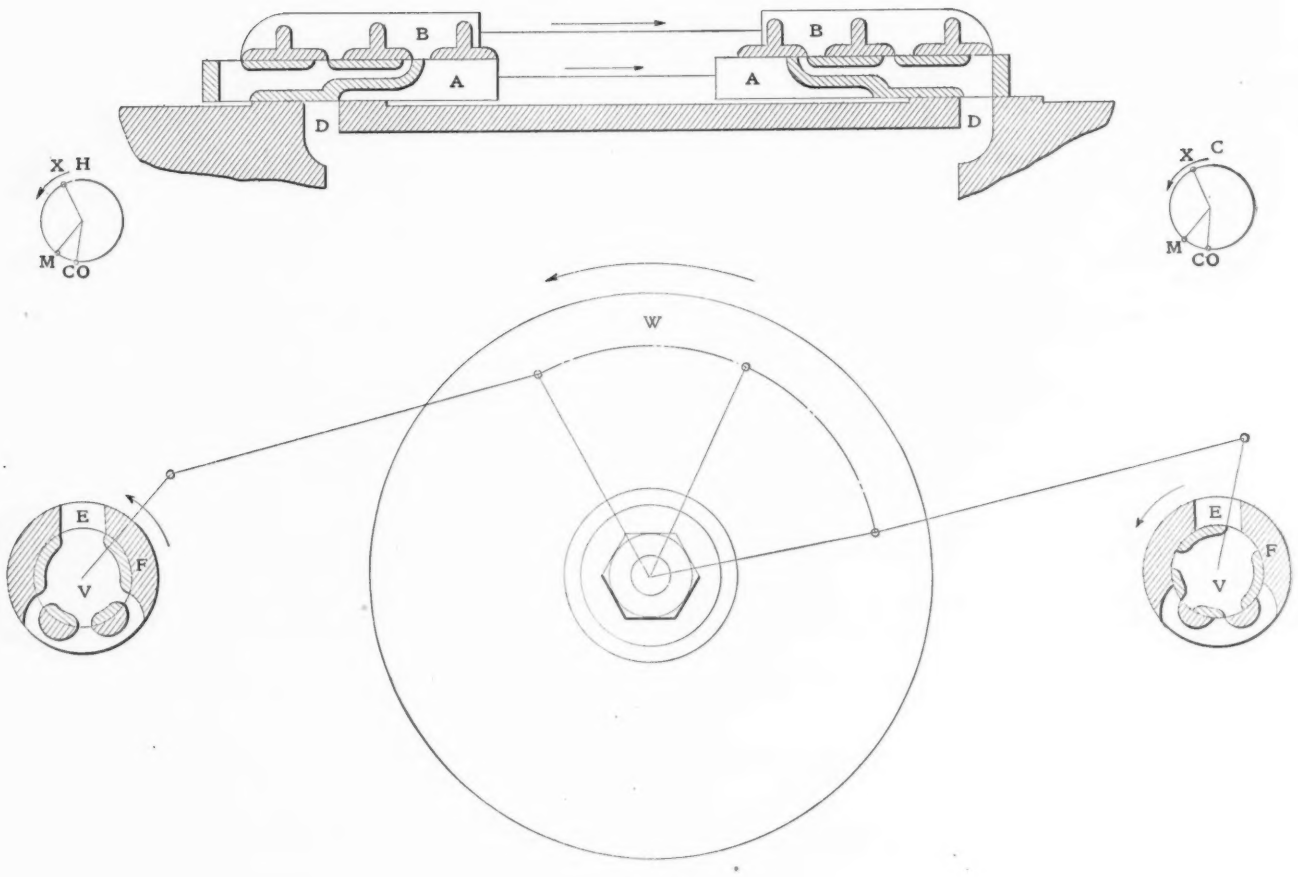


FIG. 9

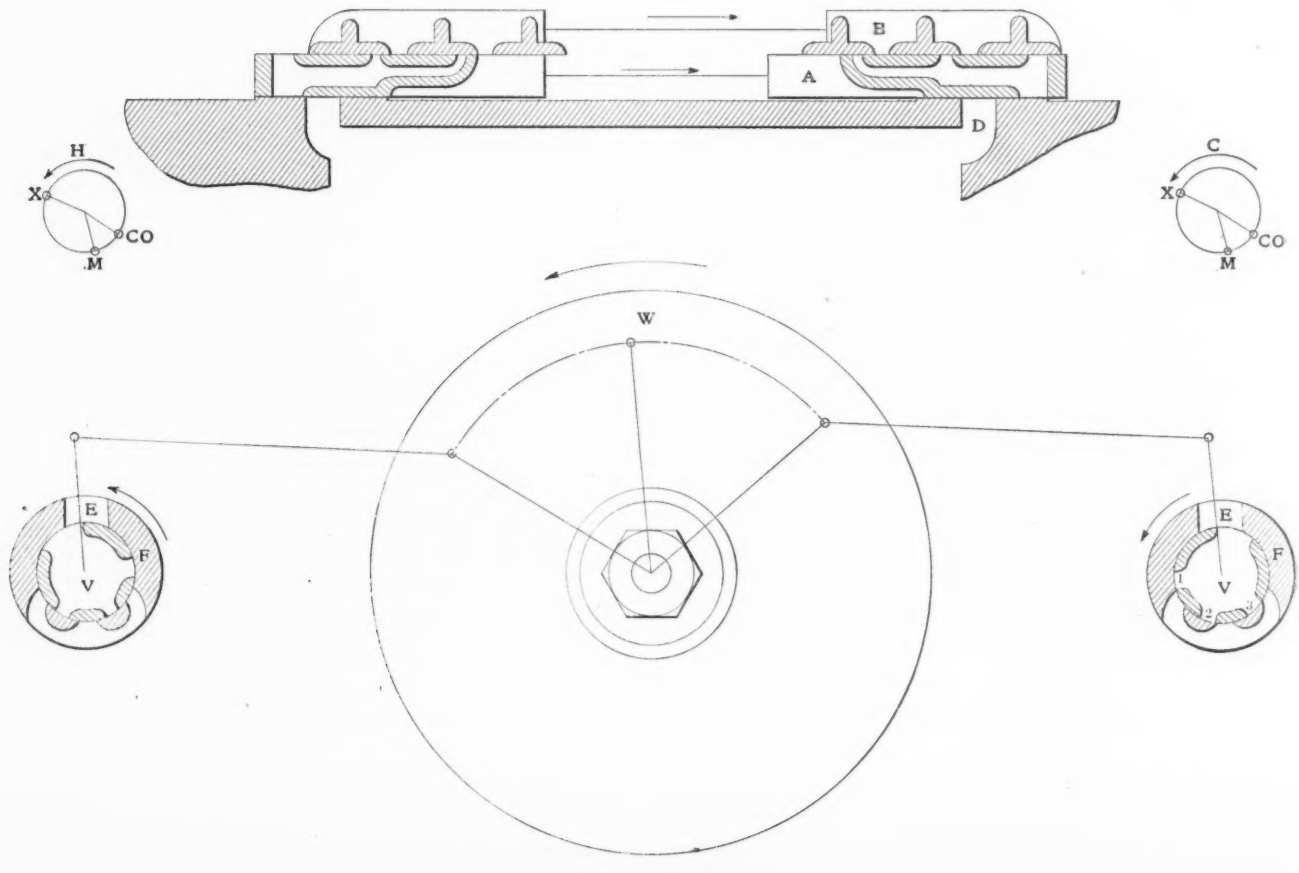


FIG. 10

rocker arm to the exhaust wristplate. Connect the two valves to the wristplate by means of their respective valve rods, then adjust the length of the reach rod so that the pins *G G G' G'* are exactly level, as in Fig. 6. The exhaust wristplate will then be central. This can be verified by placing a mark on the wristplate hub and on the washer at the end, and by noting if the mark on the hub moves exactly the same distance each side of the mark on the washer in one revolution.

With the main rocker arm still in a central position, place the main steam valve in a central position over the ports as it appears in Fig. 6, put in the valve stem connecting it with the rocker-arm pin and with the adjusting nuts on the valve stem secure the valve in place. A good method of ascertaining the accuracy of this adjustment of the valve to its seat is to scribe a line along the admission edges of the main valve on the valve seat. By moving the valve over it can be observed if the lines on each end of the valve seat are the same distance from the edge of the cylinder port. When this has been done, set up on the adjusting nuts on the valve stem and sheath nut on the eccentric rod and proceed to set the eccentric to give lead to the steam valve.

First set the engine on one center and roll the eccentric ahead of the crank in the direction the engine is to run until the proper lead is given to the main steam valve. Then make the eccentric fast to the shaft. The builders allow about 5/32 inch steam lead. Place the engine on the opposite center and note if the lead is the same. If there is much discrepancy between the two ends, even it up on the valve rod, but allow slightly more lead on the head end.

After securing the main eccentric in position, turn the engine over until the main valve is in a central position again. Then proceed to pull around the governor wheel with its cutoff eccentric and even up the throw of the cutoff rocker arm in the same manner as the main rocker. Then place the cutoff valve in a central position on top of the main valve, so that its outside cutting edges are equidistant from those of the main valve, as in Fig. 6, and secure the valve in place with its valve stem fast to the rocker-arm pin.

To set the cutoff eccentric, rotate the engine in the direction it is to travel until the crosshead has moved about 5/32 inch from the end of its stroke. Block the governor weights out against their outer stops in the position shown by the dotted lines in Fig. 5, and then revolve the governor case until the cutoff valve has just closed the ports of the main valve. In this position the eccentricity of the cutoff and main eccentrics will be about 150 degrees apart. Now fasten the governor case to the shaft with the weights still blocked, turn the engine to the next center and note if the cutoff is the same. It may not be quite the same owing to the angularity of the rods, etc., but make no changes yet. Allow the weights to come to rest on the hub of the governor, turn the engine until cutoff occurs on one end. Make a note of how far the crosshead has traveled to get the maximum cutoff, then turn the engine until the cutoff on the opposite end occurs and note the difference. If there is a marked difference in the minimum cutoff, alter the length of the valve rod to even it up and keep it down to 5/32 inch of the crosshead travel, or practically zero.

After fastening the governor case in place, proceed to set the exhaust valves for compression. Starting with the crank on one center, turn the engine in the direction of its travel until the crosshead is within 2½ inches of the end of its travel, and then set the exhaust valve, on the end opposite to which the crank started from, so that its edges are line and line with the edges of the ports, with the valve traveling in the direction to cut off or close. By taking the back bonnets off the exhaust-valve chest, marks will be observed on the end of the plugs and valves which correspond to the cutting edges of both. The valves can be set by these marks. The exhaust-valve cranks are clamped to the valve stem, as shown at *B* and *C*, Fig. 2, and by loosening up on these clamps the valves can be turned while they are being set to suit the conditions.

After setting the valves, go over all nuts on the valve and eccentric rods and fasten them securely, also the main eccentric and governor. Replace the back bonnets on the exhaust chests, and in placing the steam-chest cover in position, be sure to have the plates *S S*, Fig. 3, and the springs under them in proper position. After everything is adjusted and

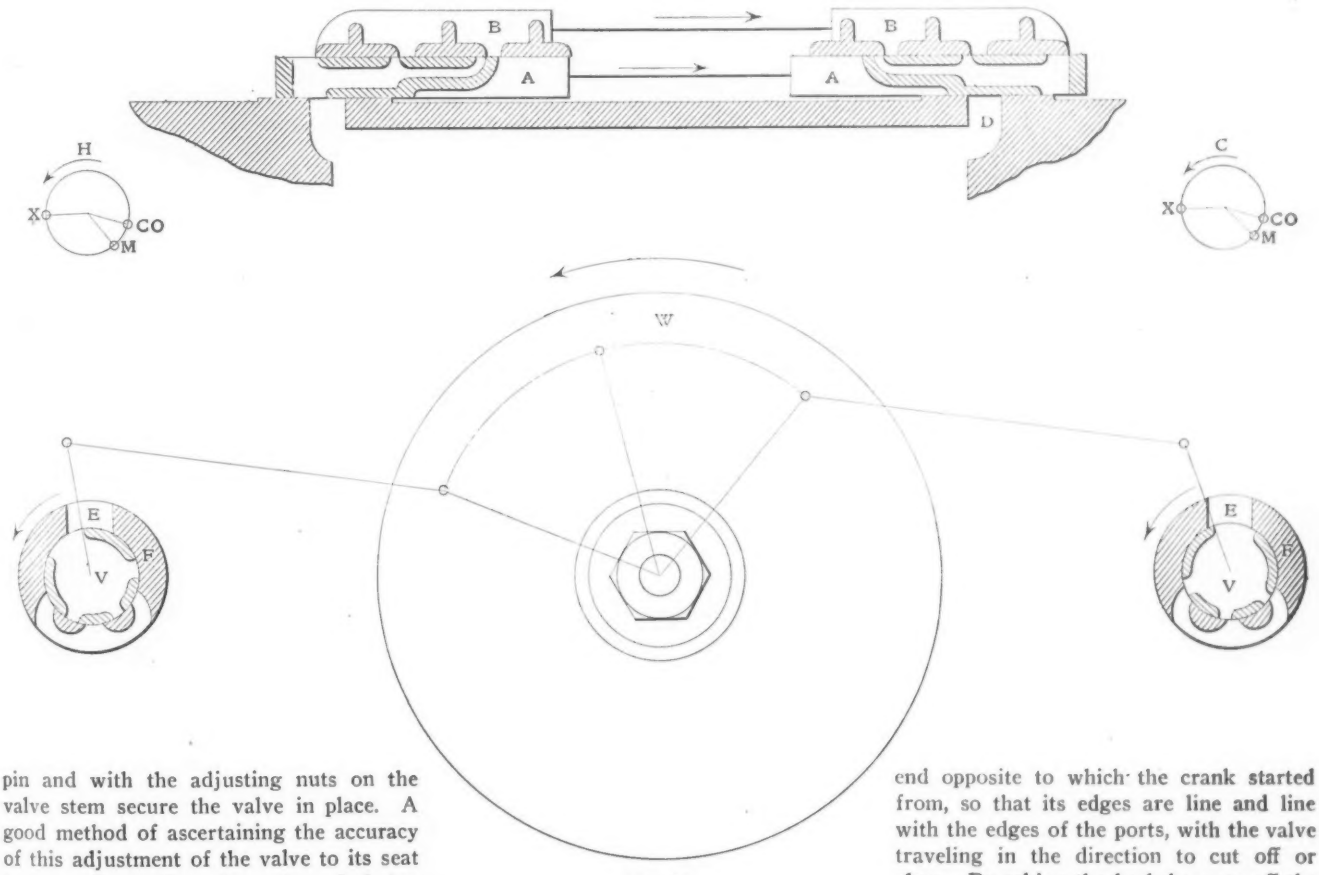


FIG. 11

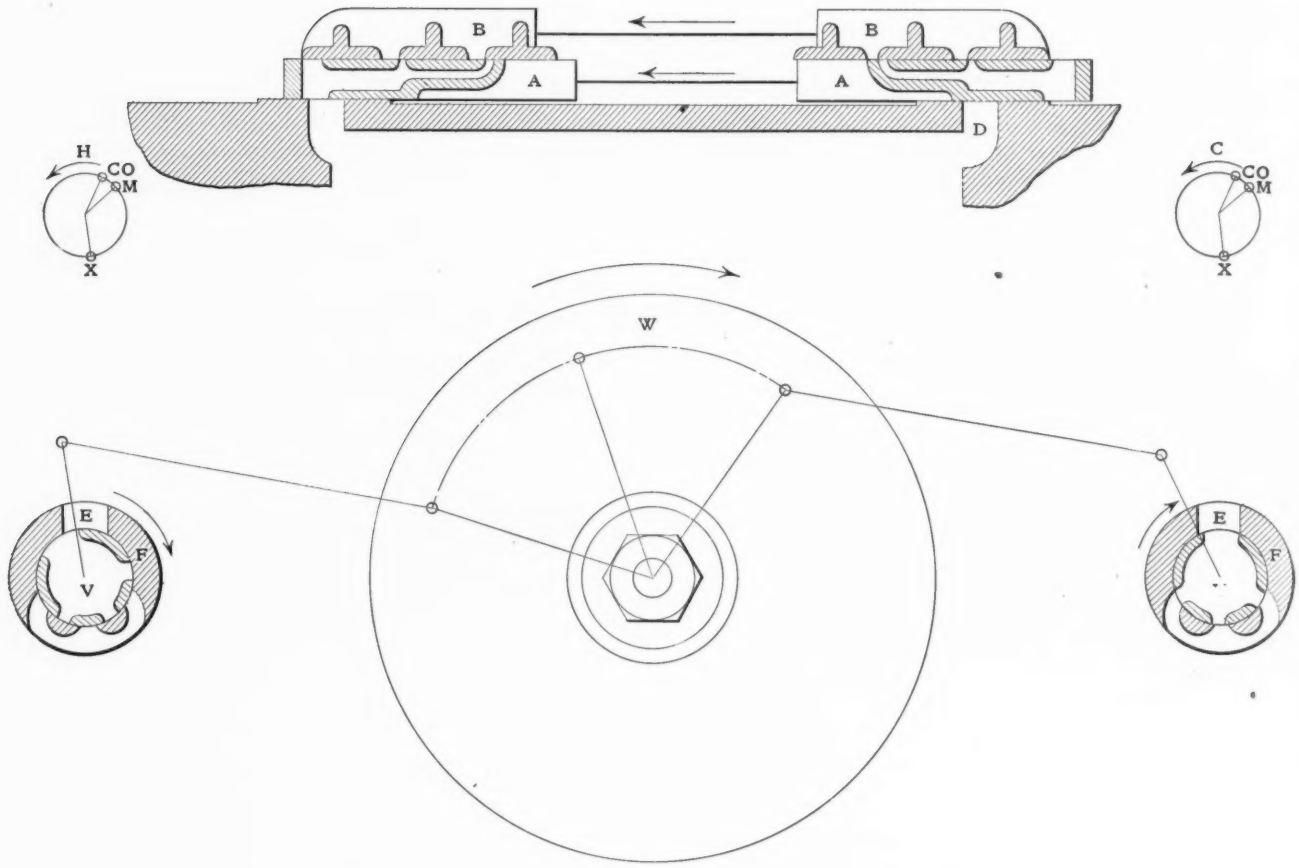


FIG. 12

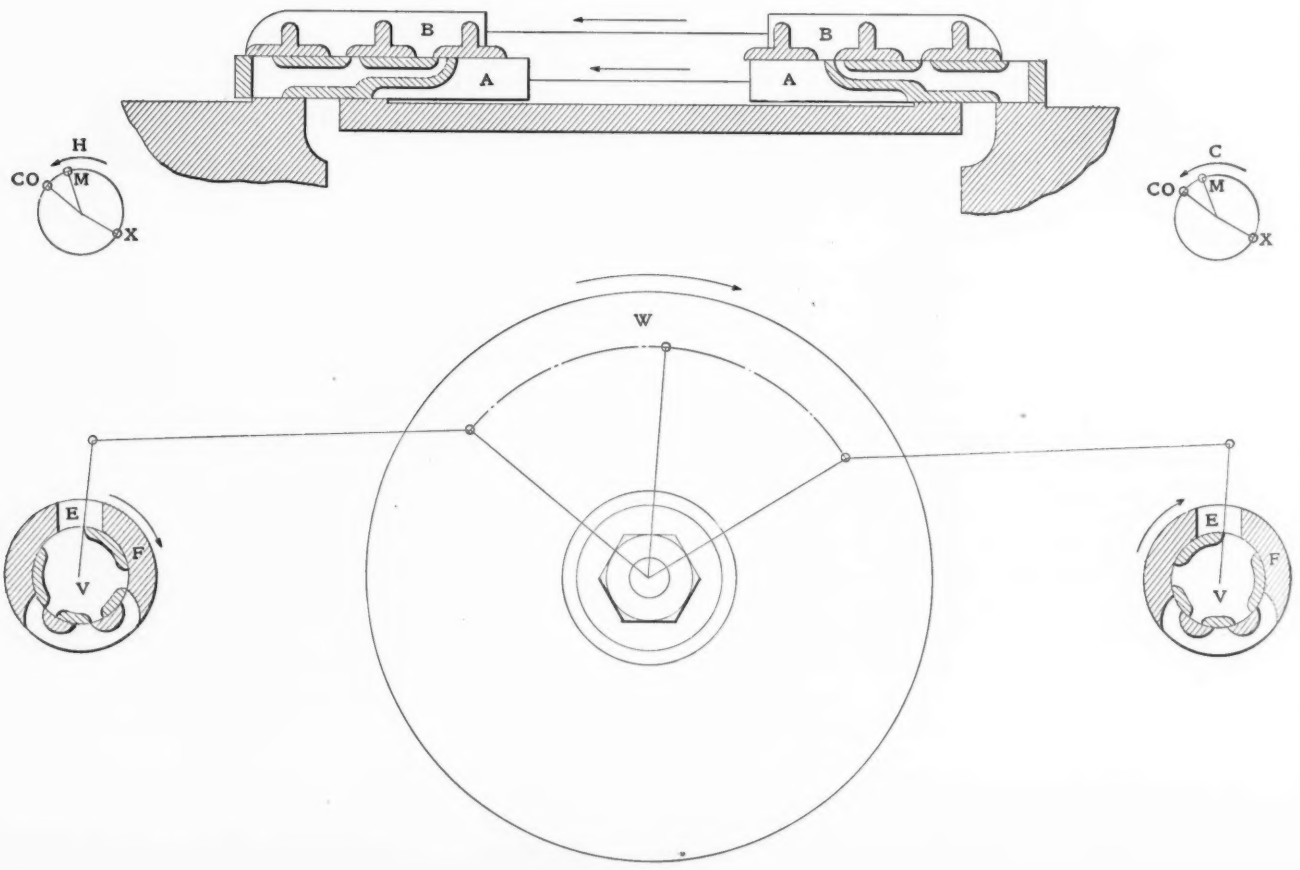


FIG. 13

the covers fast, try the governor by moving the weights by hand in and out to see that they are perfectly free and that the steam valves are not pinched under the cover. Then place the governor springs in position with proper tension.

The Governor

To know that the governor is properly assembled and in correct position on the shaft, note the following: On a right-hand engine running over, the parts will

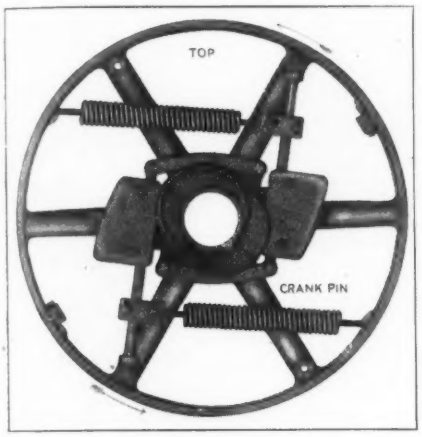


FIG. 14. CENTRIFUGAL GOVERNOR

be mounted as in Fig. 14, with the right-hand weight arm hanging down and the left-hand arm in the position shown. This arrangement also holds good for a left-hand engine running under. To change from a right-hand engine running over to a left-hand engine running under, the wheel would be turned around side for side. On a right-hand engine running under or a left-hand engine running over, the weight arm will hang downward on the left, the pin being placed in the vacant hole seen at the top of the spoke. To change from a right-hand engine running under to a left-hand engine running over, turn the wheel around side for side. In other words the weight must always follow the pivot pin of its arm in the direction of engine travel.

The governor is of the centrifugal type and regulates by advancing the eccentric or retarding it in its position in relation to the crank, thus hastening or holding the point of cutoff without altering the travel and the lap of valve remaining the same. The weights are pivoted at the ends of the arm by the pins near the rim of the wheel, and their outward motion is resisted by springs. The eccentric is fastened to each weight arm by links and is counterweighted to offset the weight of the reciprocating parts attached.

When first working the engine up to speed for the purpose of adjusting the governor, screw up on the springs and keep setting the weights out farther on the arms until the speed and sensitiveness are about right.

Then to get more speed, set up on the springs or take off weight.

To get less speed, slacken the springs or add weight.

To make the governor less sensitive, slacken the springs and take off weight.

To make the governor more sensitive, set up on the springs and add weight.

To correct for sluggishness, set up on the springs.

Generally speaking, when the governor regulates closely and a change in speed is desired, the spring tension should not be changed, but the desired speed should be obtained by changing the weights. More weight gives less speed, and less weight more speed. Moving the weights toward the rim of the wheel, or moving the spring clip on the weight arm toward the weight to get more purchase, has the effect of less weight. Moving the weights toward the hub of the wheel, or the spring clip away from the weight, has the effect of more weight.

To move the spring clip too far affects the sensitiveness of the governor as well as the speed, and a radical change should not be made without the advice of the builders. When changes of tension on the spring or in the amount of weight are made in any way, the same amount of change should always be made on each spring or weight, as the case may be. To change the direction of rotation on one of these engines, turn the eccentrics to positions opposite to those for the initial direction and hang the weight arms according to the directions here given.

Catechism of Electricity

841. *Show by means of a diagram how the losses in a motor vary with the load.*

Fig. 273 shows the variation of these losses in a 15-horsepower direct-current motor working on a constant-potential circuit. The field-winding current and speed being constant at all loads, the losses due to the resistance of the field winding, the friction of the moving parts and the armature-core loss are practically the same for all loads. The armature current, however, will vary as the load changes and this causes the armature-winding loss to vary as shown. The scales at the side of the diagram give in watts and the equivalent horsepower the electrical power supplied to the motor. The scales at the bottom give in the same terms the output of the motor.

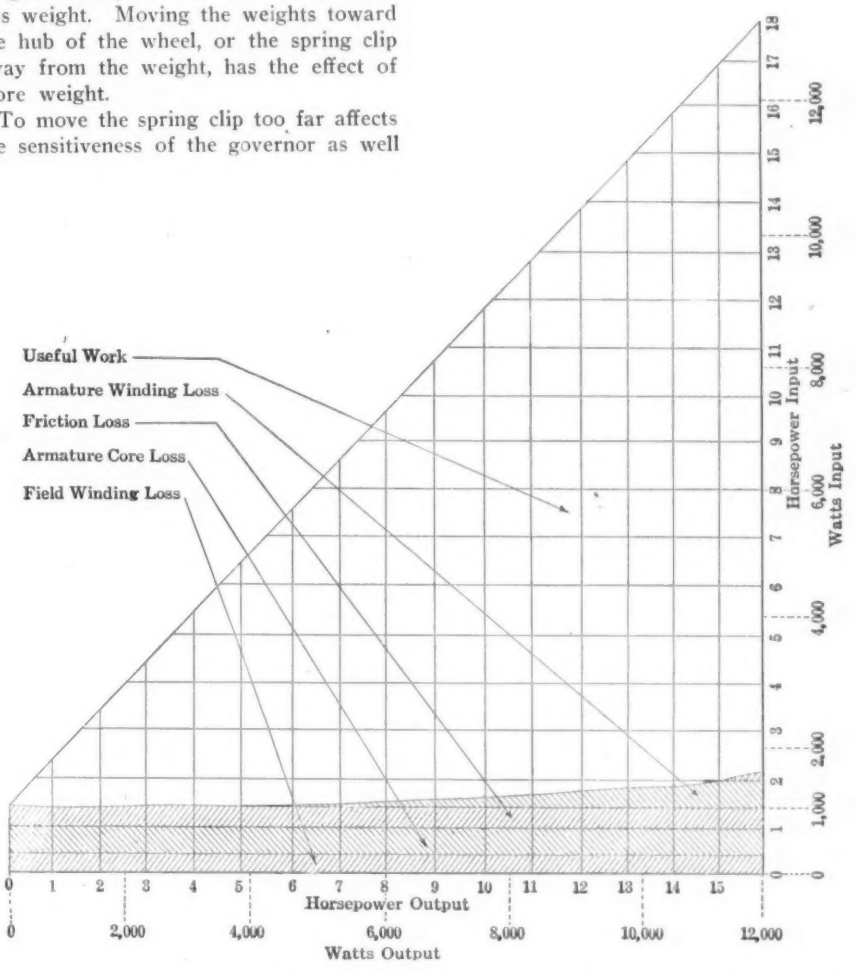

Useful Work
Armature Winding Loss
Friction Loss
Armature Core Loss
Field Winding Loss
Horsepower Input
Watts Input
Horsepower Output
Watts Output
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0 2,000 4,000 6,000 8,000 10,000 12,000
0 1,000 2,000 4,000 6,000 8,000 10,000 12,000

FIG. 273. DIAGRAM SHOWING DISTRIBUTION OF LOSSES IN A 15-HORSEPOWER DIRECT-CURRENT MOTOR ON A CONSTANT-POTENTIAL CIRCUIT

842. *How much electrical power must be given the motor represented by the diagram in Fig. 272 to make it give 4 horsepower?*

Follow the straight line from the 4 horsepower point at the base of the diagram up to the slanting line and then follow at right angles a line to the side scale, where it will be seen that the neces-

sary electrical power for this case must be 4000 watts, or about 5.4 horsepower.

843. *What is the electrical efficiency of a motor?*

The electrical efficiency is the ratio of the total power developed by the motor (not the net power delivered by it) to the total power supplied it.

844. *How does the commercial efficiency of a motor vary with the load?*

The commercial efficiency decreases as the load decreases. This may be seen from Fig. 272, for at 13.5 horsepower it is $13.5 \div 15.4 = 88$ per cent., and at 4 horsepower it is $4 \div 5.4 = 74$ per cent.

Principles of Alternating-current Motors

845. *How does an alternating-current motor differ in construction from a direct-current motor?*

The chief difference between them is the absence of a commutator in the synchronous alternating-current motor.

846. *Explain how an alternating-current motor operates without a commutator.*

A commutator is used on a direct-current generator to convert the alternating current developed in the armature winding into direct current, and in a direct-current motor to change the direct current again into alternating current for use in the armature. Suppose, now, the armature windings of a direct-current generator and of a direct-current motor be connected together with their commutators omitted. Apparently, the same conditions would exist as with the use of the commutators, but that is not entirely true. The motor would run satisfactorily only when the alternating impulses from the generator caught the armature coils of the motor systematically in the same positions in which reversal would be accomplished by a commutator. Consequently, for a certain speed of the generator the impulses will be efficient only when the armature of the motor is revolving at such a speed that each coil passes its proper reversal point simultaneously with each reversal of the generator current. With the same number of poles on both generator and motor, this condition will be satisfied only when both are running at exactly the same speed, at which time they are said to be "in step" or "in synchronism;" hence a motor so operating is called a "synchronous" motor.

847. *If the number of poles on the motor is not the same as on the generator, will the motor operate satisfactorily?*

Yes; when the speed of the motor is such as to satisfy certain conditions.

848. *What are the conditions to be satisfied?*

The number of field-magnet poles on the motor, multiplied by the speed of the armature in revolutions per minute must be equal to the number of poles on the generator multiplied by the speed of its armature in revolutions per minute. For example, if an 8-pole generator, running at 1200 revolutions per minute, supplies current to a 6-pole motor, the motor must run at $8 \times 1200 \div 6 = 1600$ revolutions per minute.

849. *Is the speed of a synchronous motor expressed in other terms than the speed of the generator and the number of poles on the machine?*

Yes; but the speed and poles of the generator determine the matter after all. The speed of the motor in revolutions per second is equal to the product of the frequency of the supply current divided by half the number of poles on the motor. Representing the frequency in cycles per second by f and the number of field-magnet poles by p,

$$\frac{2f}{p} = \text{revolutions per second.}$$

The frequency, however, is equal to half the number of poles on the generator multiplied by the revolutions of its armature per second.

850. *Are there any disadvantages inherent in the synchronous motor?*

The synchronous motor possesses several disadvantages, one of which is its inability to start up from rest without outside assistance. It is usual, therefore, to start a synchronous motor unloaded or very lightly loaded by some mechanical means so that its speed is such that it will be in step with the generator supplying it, before closing the circuit between them.

851. *Has the synchronous motor any other disadvantages?*

A second disadvantage is that its field strength must bear a definite relation to the load. So long as the load is no greater than the torque of the motor is sufficient to pull, the motor, after being properly started, will continue to run at synchronous speed. However, the moment the drag due to the load exceeds that exerted between the magnet poles and the armature, the speed will decrease and the motor will drop out of "step."

852. *What should be done when this occurs?*

The motor should be cut off from the supply circuit at once and the load removed until the motor has been started again.

853. *For what purposes is a synchronous motor best adapted?*

For work where there is a constant load to be driven at a uniform speed. For all purposes where 100 horsepower or more is required continuously for many hours at a time, as for example in pumping stations, the synchronous motor is very useful.

854. *What are the advantages of the synchronous motor?*

It can be adjusted to be practically non-inductive in operation, or to act like a condenser of large capacity, causing the current to lead the impressed electromotive force and thereby compensating the inductance in the circuit and improving the power factor; when supplied with current at constant frequency and proper voltage, it maintains actually constant speed unless subjected to an excessive load.

855. *What are the principal features of difference between the operating conditions of a synchronous motor and those of a direct-current motor?*

The field magnet of a synchronous motor is separately excited and therefore can be kept constant regardless of changes of load. When the load increases, more current is necessary in the armature to keep up the output, but if the frequency remains constant the counter-electromotive force of the motor cannot be decreased by decreasing the speed, as is the case with a direct-current motor; the speed is strictly constant. The increase in current is obtained by the automatic shifting of the phase relation between the motor and the alternator supplying it. Under light loads the counter-electromotive force of the motor is nearly opposite in phase to that of the impressed electromotive force, and but little current flows through the armature of the motor; as the load increases, it momentarily retards the armature until its counter-electromotive force becomes shifted in phase far enough from exact opposition to the impressed electromotive force to allow sufficient increase in the current through the motor to pull the additional load. When this condition is attained there is not any further tendency for the armature to slip, and it will remain in exact synchronism with the generator, but with the armature lagging behind the position of exact phase opposition at any instant of time.

856. *What would happen if a synchronous motor were heavily overloaded?*

Its armature would be dragged farther and farther behind the phase of the impressed electromotive force until it finally fell out of step; then it would stop running.

Small Motors in Nuremberg

Nuremberg, in common with the larger number of German cities, operates its own street-railway lines and its electric-light and gas plants, and in recent years has undertaken to furnish power to small manufacturing or other concerns. The number of motors now exceeds 1000, practically all of which are inside the city limits. These motors are for the most part small, furnishing at the close of 1907 a total of 2369 horsepower, or an average of 2.6 horsepower per motor. The city charges 20 pfennigs (4.76 cents) per hour per horsepower for smaller motors and 18 pfennigs (4.28 cents) per hour per horsepower for large motors. The user pays for connections with street wires and for the use of meter, the charges depending on the amount of power used and other conditions.—*Western Electrician.*

Vital Points in Producer Construction

Friendly Criticism and Suggestions Based on a Personal Investigation of Twenty Representative Gas Power Plants in the United States

BY F. C. TRYON

Several months ago the writer began a series of visits to producer-gas-power plants for the purpose of learning the operator's side of the story. The manufacturers of this kind of machinery are prolific in their literature describing the immense savings possible in labor as well as in fuel consumption. It was therefore the purpose of these visits and consultations to learn, as far as possible, the actual experiences of users of gas power for checking up and comparing them with the builders' claims. Another object in view was to obtain from owners, managers and operators expressions of opinion based on their experiences with the equipment they were using of what changes or improvements they would recommend, descriptions of the troubles and difficulties they had experienced and of the means they had used to overcome these difficulties.

The whole producer-gas-power problem being still in a more or less experimental stage, there is a lack of definite reliable information on the subject, and it would seem that the aggregate experience of a large number of operators would be of value not only to persons considering the adoption of this type of power plant, but to all general investigators of the subject.

In these visits, when the object was explained there was in every case a cordial welcome extended and a perfect willingness manifested to answer any and all questions, and in most cases to give a full expression of opinion as to such changes as the operators would suggest if they were installing a new plant. In this connection it is interesting to note that I have yet to find a user of gas producers and engines who would prefer steam power or who would install a steam plant if he were going to put in a new one. Some of them have had unpleasant experiences in getting their gas-power plants into satisfactory working condition, but a large number of these trace their troubles to insufficient capacity in some part of the installation. The following suggestions are based directly upon the experiences of these users, and the dimensions of apparatus recommended reflect the aggregate opinions of the majority of operators visited.

Relation of Dimensions to Output

In selecting a gas-producer plant it is a safe proposition to consider the capacity of each of the several parts that makes the complete unit and finally to select such sizes as seem likely to produce results required with the least trouble and least expense of upkeep. A few dollars more expended in the original outlay may result in the saving of as many dollars a year in renewals and repairs.

One of the principal troubles is that manufacturers of producer-gas plants have been trying to get the price down to about the same per horsepower that steam boilers are sold for, and in order to do this have increased the rating of the producers per unit of inside cross-section of the generator. If a steam boiler were offered to supply an engine of stated horsepower and its heating surface or grate surface were less than the standard which has been established, the purchaser would immediately know that the seller was attempting to supply a boiler too small for the work required, but gas producers seem to have no standard of rating and are offered in almost as many different sizes per unit of engine output as there are different manufacturers. If sizes are named at all, they are usually the outside diameter and hight of the generator, without any mention of the thickness of linings, etc. As floor space is usually a valuable consideration, that producer manufacturer who names the size occupying the least of this valuable space often scores an advantage with the prospective purchaser.

GENERATORS.

H. P.	Inside Diameter.	Outside Diameter.	Hight.
25	2 feet 0 inches	3 feet 6 inches	6 feet 6 inches
35	2 feet 4 inches	3 feet 10 inches	6 feet 10 inches
50	2 feet 10 inches	4 feet 4 inches	7 feet 4 inches
60	3 feet 1 inch	4 feet 7 inches	7 feet 7 inches
75	3 feet 6 inches	5 feet 0 inches	8 feet 0 inches
100	4 feet 0 inches	6 feet 0 inches	8 feet 6 inches
125	4 feet 6 inches	6 feet 6 inches	9 feet 6 inches
150	4 feet 10 inches	6 feet 10 inches	9 feet 10 inches
175	5 feet 3 inches	7 feet 3 inches	10 feet 3 inches
200	5 feet 8 inches	7 feet 8 inches	10 feet 8 inches

Wet Scrubbers.

H. P.	Diameter.	Hight.
25	18 inches	9 feet 9 inches
35	21 inches	10 feet 3 inches
50	26 inches	11 feet 0 inches
60	28 inches	11 feet 5 inches
75	32 inches	12 feet 0 inches
100	36 inches	12 feet 9 inches
125	41 inches	14 feet 3 inches
150	44 inches	14 feet 9 inches
175	48 inches	15 feet 5 inches
200	51 inches	16 feet 0 inches

Dry Scrubbers.

H. P.	Diameter.	Hight.
25 (single)	24 inches	3 feet 0 inches
35 (single)	28 inches	3 feet 0 inches
50 (double)	34 inches	6 feet 0 inches
60 (double)	37 inches	6 feet 0 inches
75 (double)	42 inches	6 feet 0 inches
100 (double)	48 inches	7 feet 0 inches
125 (double)	52 inches	7 feet 0 inches
150 (double)	58 inches	7 feet 6 inches
175 (double)	63 inches	7 feet 6 inches
200 (double)	68 inches	7 feet 6 inches

The Generator

Small inside diameter means excessive draft through the fire. If a fire is forced, as will be necessary with too small an inside diameter, the results will be clinkers and blow holes or chimneys through the fire bed, with excess CO_2 and weak gas; clinkers fused to the lining, and burning out of grates. If sufficient steam is used to keep down the excessive heat, the result is likely to be too much hydrogen in the gas, with the attendant engine troubles.

Small outside diameter obtained by means of thin linings entails excessive radiation and low efficiency. The lining should never be less than 9 inches thick even in the smaller sizes and a 100-horsepower, or larger, producer should have at least 12 inches of generator lining. The lining next to the fire bed should be of the best quality of refractory material, and there is less conductivity of heat if the lining is built up in two thicknesses. As good a lining as any consists of a course of soft or salmon "common bricks" put in edgewise next to the steel shell of the generator and laid in good portland cement to fill all spaces; then a good firebrick 6 inches thick inside the course of common bricks, the firebricks being dipped as laid in a fine grouting of ground firebrick, using as little of the grout as possible; if the firebricks could be rubbed together until they make a close joint it would be even better than the grout. These firebricks should be the cupola or key shape made to fit the circle of the inside diameter of the generator, and all arches should be built from bricks especially designed to fill the spaces they are to be used in.

If we take 1¼ pounds of coal per horsepower-hour as a fair average of combustion and 10 pounds of coal per hour per square foot of internal fuel-bed cross-section, with 9 inches of refractory lining up to 100 horsepower and at least 12

inches of lining on all larger sizes, the generator will give good gas without forcing and without excessive heat in the zone of complete combustion. Taking a 200-horsepower producer on this basis, we have 250 pounds of coal as the quantity to be gasified per hour at full load, and at 10 pounds per square foot of internal area 25 square feet will be necessary; this means a cylindrical space 68 inches in diameter, and with a 12-inch lining the outside diameter will be 92 inches.

Another requisite to be taken into consideration is the depth of the fuel bed in the generator. Practice has shown this should never be less than the inside diameter up to 6 feet; above this size the depth can be adjusted by the operator as his experience indicates the best working results. The total hight of a generator will therefore be the aggregate of the space required under the grate, the thickness of the grate, sufficient space for ashes on the grate to prevent the grate from burning out, a depth of fuel bed equal to the diameter, and whatever storage capacity for fuel is desired above. Assuming again for a 200-horsepower producer 18 inches for the ashpit below the grate, 12 inches for the thickness of the grate and the ashes to protect the grate, 68 inches depth of fuel bed, 24 inches above the fuel to the gas outlet, the hight will be 10 feet 4 inches to the top of the generator; above this the coal-feeding hopper, say 32 inches high, is mounted; this makes the hight over all 13 feet. Such a producer should have a working platform around the top of the generator of sufficient size to enable the operator to handle his bars, pokers and tamps, without having to stand directly on the top of the generator while doing his work. A comfortable stairway, with easy rise and tread and hand rails, from the floor of the producer room to the platform should also be provided.

If a movable grate is used to work the ashes, there should be provided a door or opening of sufficient size to allow the cleaning of the grate, and the center of the hight of this door or opening should be at the grate level. This will allow the removal of any clinkers formed in the fire bed when worked down to the grate before they have an opportunity of becoming fastened or fused to it.

If the air is heated before it enters the generator under the grates, the size of the air inlet should be proportioned according to the amount of the expansion of the air by the heat it has absorbed. In a suction producer no more air will be drawn into the generator than is necessary to make the gas the engine requires, no matter how large the air inlet, but it is necessary that this air inlet be controllable; sometimes, as when the producer is not in operation, it should be entirely closed.

The Vaporizer

In order to make steam for the producer some builders provide coils of pipe inclosed in the gas pipe between the generator and the scrubber, the hot gas coming in direct contact with these coils, to which the water is led, and the outlet of the coils being in the air pipe leading to the bottom of the generator. Unless such coils are kept full of water they will soon burn out, and if kept full of water the flow of steam to air inlet is not controlled by the volume of gas being made. With a steady flow of steam into the generator, the composition of the gas being made will be changed with every change of the load of the engine; on the other hand, if the flow of steam is regulated to vary with the volume of gas being made, then the pressure of steam in the vaporizer coils will change every time the load changes. Another difficulty with vaporizing coils, due to impurity of the water, is the deposit in the coil, which it is almost impossible to clean out. If the steam is generated elsewhere and run through a coil to superheat it, there is less liability of this trouble, as the larger percentage of solids in water is in the form of carbonates which separate and deposit at steam-making temperatures.

In other types of producer a corrugated pipe is used to convey the gas from the generator to the scrubber; this is jacketed and water is trickled on the outside of the corrugated pipe and vaporized. The air is drawn through the same space and is also heated and absorbs the steam, carrying it into the fuel bed. In this type the amount of water fed to the vaporizer is regulated by the vacuum in the gas main. This seems to give as nearly automatic regulation as has been devised.

In other types of producer the water for steam purposes is dropped upon a hot plate near the bottom of the generator around the fire bed just above the grate. This has the disadvantage of absorbing heat from the fuel bed instead of utilizing waste heat.

There are some producers which do not pre-heat the air admitted to the generator, but take the air directly from the producer room through doors under the grates; the builders claim that the saving of grates by letting the air keep them cooled is worth more than the heat conserved by utilizing the waste heat of the outgoing gas, but they seem to forget that every heat unit taken from the gas between the generator and the scrubber leaves that much less heat to be washed out in the scrubber, which effects a saving of water required for the plant.

The Wet Scrubber

The wet scrubber of a gas producer should be of ample size to cool the gas to atmospheric temperature or lower, and wash out most of the impurities. For this apparatus a good rule to use is to make its diameter three-fourths that of the inside diameter of the generator and the hight one and one-half times the hight of the generator shell. For example, if a 100-horsepower producer were 4 feet inside diameter the wet scrubber should be 3 feet inside diameter, and if the generator shell is 8 feet 6 inches high, the scrubber should be 12 feet 9 inches high. When filled with the proper amount of baffling and scrubbing material, the scrubber will have space for about 30 cubic feet of gas. A 100-horsepower gas engine running at full load and using 12,000 B.t.u. per horsepower-hour will use 160 cubic feet of 125-B.t.u. gas per minute. The wet scrubber will therefore be emptied five and one third times every minute, or, in other words, the gas must be washed and cooled in about eleven and one-third seconds and would require about 8⅓ gallons of water per minute; if the diameter of the scrubber were reduced one-third the volume of water necessary to cool and scrub the gas would have to be doubled. Gas must be cooled below 90 degrees Fahrenheit to enable it to give up the impurities it carries in suspension and even lower than this to let go its moisture. If the gas passes warm into the dry scrubber, the baffling materials in the dry scrubber will require changing much oftener than when the gas is properly cooled.

Some manufacturers of producers provide wet scrubbers filled with wooden slats laid in lattice form. The sprinkler above them keeps the whole mass wet, and the gas passing through the small spaces and changing its direction of flow at every layer of slats is thoroughly cooled and gives up its suspended impurities. The manufacturers claim that by flooding the wet scrubber occasionally with water the deposited impurities are washed from the slats. It is certainly quite a job to remove and replace them if it should become necessary, and some operators after removing the slats a couple of times have thrown them away and substituted coke in their place as being less expensive and easier to clean.

In most wet scrubbers the baffling and scrubbing material is coke and in nearly all plants the wet scrubber has only one compartment, with one tray at or near the bottom and a door or manhole opening just at the top of this tray. When necessary to clean out the scrubber, all the material is removed through the door or manhole, and it is replaced through the top, the opening at the tray being closed. Other wet scrubbers have a number of trays with large openings at each tray, so that any of the compartments can be examined and cleaned if necessary and refilled. The single compartment appears to be easier to care for, notwithstanding the necessity for taking out all of the coke for cleaning.

Sprinklers of a type not likely to become clogged or stopped should be provided in or near the top of wet scrubbers. The sprinkler should preferably be

of a kind and size to fill thoroughly with spray or mist the space in which it is located, that the tray immediately below the sprinkler may be thoroughly drenched with water at all times. If a number of trays are used and there is a space between the top of the baffling material on one tray and the next tray above there is less likelihood of the water passing down through the scrubber in streams; it will trickle from tray to tray and absorb more heat from the gas passing through it. Another good plan is to have one or two trays of material above the spray to absorb any moisture the gas may carry in suspension after passing through the spray. The space or spaces above the spray can be filled with oil-soaked excelsior. If the pores of the excelsior fiber are filled with oil it cannot absorb moisture, but will gather the moisture on the surface and when sufficient for a drop is accumulated, it will drop into the water space below.

The Dry Scrubber

Many manufacturers of producer-gas plants do not provide a separate dry scrubber, but utilize the space in the top of the wet scrubber as a dry scrubber. This is not good economy. A separate dry scrubber with two compartments should always be provided and the piping between the two scrubbers so arranged that the gas can be turned into either part of the dry scrubber at will. The dry scrubber should be equal in area to the inside of the generator and the depth of each part should be sufficient to accommodate at least 2 cubic feet of scrubbing material and give 1 cubic foot of space next to the outlet. Here, again, oil-soaked excelsior is a good scrubbing material and should be packed as closely as possible.

Suction Pipe Vacuum

Another matter to be given careful consideration is the size of the delivery pipe of the simple suction producer or of the induced-draft type, where an exhauster is installed between the wet and dry scrubbers and the gas is delivered to the engine under a slight pressure. There are some plants in which the vacuum between the engine and the producer is as high as 12 inches and some as low as 2 inches. With 2, or even 4, inches of vacuum the engine can draw the gas it requires without difficulty, but when 6 inches or higher vacuum is required, an exhauster can be installed and driven by separate power with a saving. If a suction producer plant is so arranged that its vacuum changes from time to time as the fire changes, it is rarely advisable to put the extra load on the engine. Suction producers up to, say, 200 horsepower, are entirely practical; for any size above this it is safer and more economical to operate the induced-draft type.

In any size where the gas is to be used by more than one engine, or where gas is used both for heating or furnace work and for power, it is better to install the induced-draft type. The exhauster will take care of all the gas made, supplying the engine as well as the furnaces and obviating the liability of one robbing the other. If the exhauster is properly connected and by-passed it will take care of any variation of load or draft on the gas-supply main. When the gas is delivered to the engine under pressure it is important that the pressure should be throttled, if necessary, to about atmospheric pressure at the intake of the engine; otherwise, it is liable to affect the air supply at the mixing chamber. This control can be effected either by a pressure-reducing valve or by a small gasometer; the latter will probably be more satisfactory.

Complete Producer Dimensions

Taking as the standard the dimensions previously stated for the different parts of a producer-gas plant, a list of dimensions for different horsepower capacities would be about as in the tables on page 909.

A gas producer for the use of pulverized fuel (*Le Genie Civil*, Vol. LI) consists of a receiver, circular in plan, lined with refractory material. Near the bottom and almost tangential to the circumference of the lining is inserted the discharge pipe of a fan blower by means of which the pulverized fuel, together with the requisite quantity of air, is introduced. The producer is started by making a wood fire and then blowing in the coal dust by means of the fan. A very high temperature is produced which slags much of the ash, which is withdrawn every six or eight hours, this being the only cleaning required. Owing to the high temperature the tar is converted into gas. The largest plant at present using this system yields 600 horsepower continuously from an inferior quality of coal.

First Boiler Plate Mill in America

By W. S. Atchison

In presenting this brief history of the origin and development of the "Old Mill," it is necessary to state that while it was widely known as having been established in 1810, the actual and original establishment of the works dates back to the year 1790, when Isaac Pennock, the great-grandfather of the present management, built a mill and began the manufacture of iron at a place now called Rokeby, and situated on Buck Run, Chester county, Pennsylvania, about four miles south of Coatesville. He was signally successful in this pioneer industry, notwithstanding that he had been raised a farmer and ventured into a business with which he was entirely unfamiliar.

"THE OLD MILL"

The mill first built was called the "Federal Slitting Mill." Charcoal slabs were heated in an open charcoal fire, rolled out into plates and then slit up into rods for general blacksmith use. In 1810 he bought a sawmill property on the Brandywine at Coatesville, which he converted into an iron mill known at that time as the "Brandywine." It was, therefore, in the year 1810 that the "Old Mill" was located on the site which has been developed into the large plant now in operation, covering many acres of ground and giving steady employment to a large number of men.

In 1816, Dr. Charles Lukens, a son-in-law of Isaac Pennock and grandfather of the present management, came into possession of the property and carried on the business of iron making up to the time of his death in 1825. It was between these dates that the first boiler plates produced in this country were made in this mill.

Doctor Lukens died at an early age, and in accordance with his special re-

quest, was succeeded by his widow, Rebecca W. Lukens, who continued successfully to carry on the business, although severely handicapped by the fact that in those days there were no railroads. The finished material had to be teamed to Philadelphia, a distance of 38 miles, or 26 miles to Wilmington, while the coal used was hauled from Columbia, about 42 miles away. However, in spite of these difficulties, she carried on the iron-making business with the assistance of a superintendent to look after the works and employees, while she herself assumed full control and management of the commercial end. Mrs. Lukens was considered an extraordinary business woman, and she built up a business which has remained in the family for four generations and has been continuously successful up to the present time. It was in her honor that the name of the works was changed from "Brandywine" to "Lukens."

Originally the plates were made from single charcoal blooms, the blooms being made in the old-fashioned forge fire, then reheated over an ordinary grate fire and rolled into plates or sheets. The plates were shipped without being sheared; the shearings in those days were cut into nails. Afterward a reverberatory heating furnace was introduced, enabling the scrap to be worked up. The plate rolls of that time, as nearly as known, were about 16 to 18 inches in diameter and from 3 to 4 feet long between the housings, being driven by an overshot water wheel. It is said that many times when it looked as if the mill would stall, the workmen would rush for the water wheel, climb up on the rim and by their united weight help the "pass" through the rolls, thus preventing a "sticker," which invariably meant fire-cracked rolls and later on broken ones.

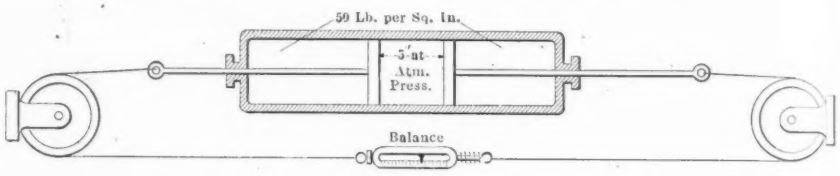
Increasing business necessitated more power and the overshot wheel was supplanted by a breast wheel, geared to convey more power to the rolls, and in addition a heavy flywheel was introduced, being one of the first examples of stored momentum applied to a water wheel. The mill was operated with this equipment until 1870, when a modern steam plate mill was erected nearby with chilled rolls 25x84 inches. The "Old Mill" was afterward used as a puddling mill to prepare stock for the new modern mill. The present property of the Lukens Iron and Steel Company covers an area of over 200 acres, upon which stand twelve large buildings equipped with the latest and most approved machinery, with a capacity of mammoth proportions.

The picture of the "Old Mill" was sketched over fifty years ago for the use of the one bank then doing business in Coatesville. From that picture the engraving was made, and the sketch still adorns the walls of the bank, which is now known as the National Bank of Chester Valley.

A Problem of Pressures

By F. C. Helms

Some time ago there was considerable space in these columns devoted to "A Simple Problem in Mechanics." I would like to submit the following solution of a little variation of this same problem, the conditions of which are presented in the accompanying illustration. A cylinder of 10 square inches internal area is fitted with two pistons, the inner faces of the two being 5 inches apart with atmospheric pressure between them. Behind each piston is a pressure of 50 pounds per square inch, gage, and the pressure exerted on the pistons is transmitted to a spring balance, as indicated in the figure. The problem is to compute the reading of the spring balance with conditions as shown in the sketch, the air being compressed between the pistons while the spring balance is being extended until the pressures are equalized. The figure given as clearance between the pistons is with the cords taut and the spring balance registering zero. To elongate the spring of the balance 1 inch requires a pressure of 100 pounds per square inch.



THE PROBLEM ILLUSTRATED

For convenience in solving let

V = Volume between the pistons in cubic inches =

$$5 \times 10 = 50,$$

$P = 14.7$ pounds per square inch = pressure of the atmosphere acting between the pistons when the spring balance stands at zero,

$P_2 = 50$ pounds per square inch, gage, forcing the pistons together,

$A = 10$ square inches = area of each piston, and neglecting piston rods, this figure will be used for either side.

It is evident that the force represented by $10\ P_2$ is counterbalanced by the tension on the spring, or $100\ X$ (where X is the distance in inches through which the pistons and the index of the spring balance move from the initial position to the position where equilibrium obtains) and the pressure of the compressed air between the pistons. Then

$$V_1 = (5 - X)\ 10 \text{ cubic inches.}$$

In order to find the value of P_1, the pressure to which the air between the pistons will be compressed when equilibrium obtains, it will be necessary to resort to Mariotte's law for compression of gases at constant temperature, which says that the product of the pressure and volume is constant for a constant mass of gas in a closed vessel. Therefore, we have:

$$P_1 = \frac{P\ V}{V_1},$$

in which P and P_1 are absolute pressures. Hence our equation of equilibrium will be:

$$10\ P_2 = 10\ P_1 + 100\ X;$$

$$647 = 10\ \frac{14.7\ (5 \times 10)}{(5 - X)\ 10} + 100\ X.$$

Cancelling and reducing we get:

$$647 = \frac{735}{5 - X} + 100\ X.$$

Clearing fractions,

$$3235 - 647\ X = 735 + 500\ X - 100\ X^2.$$

Transposing and collecting,

$$100\ X^2 - 11.47\ X = -2500;$$

$$X^2 - 11.47\ X = -25.$$

To complete the square, add the square of half the coefficient of X to each side of the equation and get:

$$X^2 - 11.47\ X + \left(\frac{11.47}{2}\right)^2 = \left(\frac{11.47}{2}\right)^2 - 25.$$

Extracting the square root,

$$X - \frac{11.47}{2} = \pm\sqrt{\left(\frac{11.47}{2}\right)^2 - 25}$$

Transposing and performing the indicated operations, we get,

$$X = 5.74 \pm 2.81 = 8.55 \text{ or } 2.93,$$

the latter value being the only one which suits the present case. This means that the spring balance will be stretched 2.93 inches, or will register 293 pounds when equilibrium obtains, while the air between the pistons will be compressed to a volume

$$V_1 = (5 - 2.93)\ 10 = 20.7$$

cubic inches, and to a pressure

$$P_1 = \frac{14.7\ (5 \times 10)}{20.7} = 35.5$$

pounds absolute, or $35.5 - 14.7 = 20.8$ pounds gage. Hence it will be seen that the equation of equilibrium approximately balances when the correct figures are substituted for the unknown quantities as follows:

$$10 \times 64.7 = (10 \times 35.5) + (100 \times 2.93).$$

The Inspection of Steam Boilers

Continuation of Instructions, Begun in Last Week's Issue, for the Guidance of the Inspector; the Right Methods Clearly Outlined

BY JAMES F. HOBART

Type of Boiler, Length and Diameter

These data should, of course, be supplied, but while the inspection details given herewith may be applied to a considerable number of other types, the inspection is more especially designed for boilers of the horizontal tubular type. With but slight changes, the inspection questions may be made to fit vertical-tubular boilers. Considerable change will be necessary when water-tube boilers are to be inspected, but the things the inspector looks for and describes are the same in all cases no matter how different may be the arrangement of the parts in fire-tube and in water-tube boilers.

The length of a boiler matters little to the inspector, as the pressure upon the heads of a boiler are the same, no matter whether the shell is 10 or 20 feet in length. It is only in the matter of support, in very long boilers, that the inspector is interested. In modern types of boiler the length is usually so short that the inspector may neglect that factor entirely.

The diameter of a boiler is a vital point of interest, as it is one of the limiting factors in ultimate strength and in safe working pressure of the shell, as applied to the longitudinal tendency to rupture. The pressure on the head of a boiler is comparatively so small that it is easily carried by the flange of the head, and it is only necessary for the inspector to see that the braces and stays which hold in place the flat-head surfaces are adequate for the purpose and are properly distributed and attached to the boiler heads. This matter is fully covered by questions 59 to 70.

Joint Efficiency

The method of calculating joint efficiency will not be discussed here, but it will be assumed that for single riveting the joint efficiency is 0.56, and that for single and double riveting the efficiencies are, respectively, 0.74 and 0.76 per cent., while the triple-riveted double-strap butt joint has an efficiency of 86 per cent. of the strength of the solid plate. Thus, the stress required to rupture a 5/8-inch shell of 60,000 tensile strength, 72 inches in diameter, joint efficiency 86 per cent., would be, with a factor of safety of five, equal to

$$\frac{60{,}000 \times 0.625 \times 0.86}{36 \times 5} = 179$$

pounds working pressure. The thickness of heads is usually increased a little to make up for the reduction of thickness during the operation of flanging. Otherwise, the head plates need not be thicker than those of the shell except for whatever strain there may be exerted by the tube flanging.

Thickness of Shell

Question 3 shows how the shell thickness vitally affects the ultimate strength of a shell. Question 4 also shows that in calculating the strength of an old boiler the thinnest place in the shell must be taken as the plate thickness in making the calculations in question. There is one thing, however, which counteracts to a

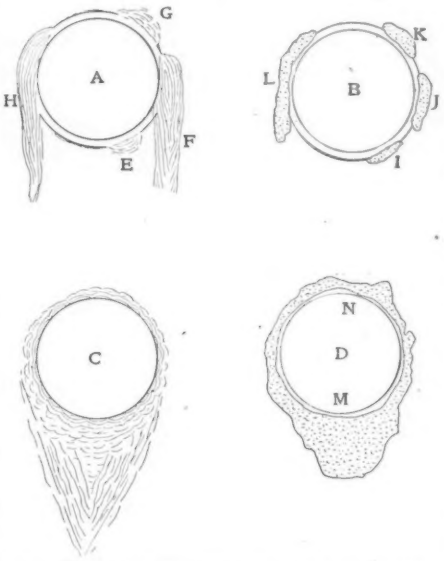


FIG. 8. WASHING OF TUBE ENDS AND CORROSION OF BOILER HEAD

certain degree the loss of shell strength by wasting away of the plate thickness. It is evident that any shell plate may waste away until it is only 86 per cent. as thick as a new plate without affecting the strength of the boiler. This wasting, however, must not take place upon the section of plate through which the rivets pass. In a butt-strap joint the rivet section cannot waste away, as that section is protected by the straps. It is then possible for a 5/8-inch shell to become reduced to 0.536 inch, or about 17/32 inch, without reducing the actual strength of the shell. It is for this reason that sometimes cases of grooving or wasting are reported as "not dangerous."

Stamps on Boiler

Look for the stamps to be found on the shell. If it should be found that the grooved sheet was stamped 65,000 pounds instead of 60,000, then the shell would be good for 194 pounds instead of 179 pounds, and the wasted sheet could be reduced 23 per cent., or to about 15/32 inch, without the wasting becoming dangerous. The name of the maker and the date of the making of the boiler are sometimes valuable in determining the tensile strength of the material of which it is made. Some boiler makers stamp with steel figures a consecutive number on each boiler turned out of their shops, thus making it quite easy to obtain the pedigree of any boiler thus numbered.

Leaky Tube Ends and Corroded Heads

Questions 8 to 11, relating to the original and present diameter of the tubes, is important for determining the holding power of any tube. When a tube becomes too much reduced in wall thickness, there is danger of its tearing loose from the head, which might be blown out were all the tubes to let go. Luckily, the failure of a boiler tube is almost invariably heralded by persistent leakage, and while some leaky tubes may hold the head securely, the presence of chronic leakage may be taken as a danger signal which should not be overlooked.

Leaky tube ends and corroded heads frequently present the appearance shown by Fig. 8, in which the sketches *A* and *C* are representations of tube ends as seen by the inspector, while sketches *B* and *D* represent the same tube ends after the dirt and rust have been cleaned off by the sharpened hook peen of the inspector's hammer. The slight deposit shown at *E*, sketch *A*, may be nothing but mud and ashes, or when cleaned off there may be found the slight rusted spot shown at *I*, sketch *B*. Sometimes slight leaks of this kind "take up" of their own accord, but when they do not close spontaneously and are allowed to continue, they usually increase in size and present the appearance noted at *F*, *G* and *H*, sketch *A*. When the deposits are finally cleaned off, it will be found that holes have been corroded in both tube and head as at *J*, *K* and *L*, sketch *B*. The remedy, when appearances like those on sketch *A* are found, is to clean off all the deposit, expand the tube until it is tight, then paint the corroded spots with red lead and raw linseed oil. Repeat the painting until the corrosion stops all action.

When a case like that shown by sketch

A is neglected, it will finally be found by the inspector to present an appearance similar to that shown by sketch *C*, and when the deposit and corrosion have been removed there may be found no tube end at all, as shown at *M*, where there is merely a paper thickness of tube end. At *N* there is a little more tube left, but it is evident that the head-holding power of a tube of this kind is only very slight, if it holds anything at all. Where there are a number of such tubes in a head, particularly if they are adjacent to each other, the case should be marked "dangerous" and reported accordingly, while the safe working pressure which may be carried by the boiler while in that condition will be greatly reduced.

It may be stated here that it is not the office of an inspector to condemn any boiler even if it be decidedly dangerous. All that the inspector should do, and all that he is expected to do, is to determine the working pressure which the boiler under inspection can safely carry. When the pressure of a 150-pound boiler has been cut down by inspection to 40 or 50 pounds to the square inch, there is no need for the inspector to condemn—the owner will do that quickly enough when he finds that he cannot operate his boiler at a pressure which pays. Thus the fixing of the safe working pressure for a boiler, between its maximum amount and zero, according to the physical condition of the boiler is all there is to be done, and it is a fine example of the importance of the inspector's work, showing the necessity for having that work done well.

Joint Efficiency

Questions 12 to 14 have been partially answered in the preceding paragraphs. The efficiency of 86 per cent. of the butt-strap joint is found by calculating separately the strength of the plate remaining after the rivet holes have been made. Then the strength of the rivets is calculated accordingly as to whether they are in single or double shear, and in accordance with their number and diameter. Then the strength of the rivet section is compared with the strength of the net plate section and the smaller one is compared with the strength of the uncut plate. When the inspector finds that the plate has wasted between the rivets, then he lowers the joint efficiency in the same ratio that the wasting has reduced the plates or the straps. If the rivets have suffered, or are in bad condition, either from wear or from poor shop work, then the inspector has no choice but to lower the joint efficiency accordingly and see that the safe working pressure gets a corresponding reduction. Truly, the boiler inspector is a man of a single idea, and that idea is to ascertain the weakest point of the boiler and then to cut down the working pressure until the strength of the weakest point is sufficient to carry that pressure.

Defective Plates and Leaky Seams

Questions 15 to 20 are to be treated the same as the tube-end questions. Find a weakness, if there is one, then determine its extent and its weight toward lowering the safe working pressure. Questions 21 and 22 relate to a persistent tendency of boilers with dry sheets to burn off the edge of the sheet whenever the fire-door arch becomes defective and allows flame to shoot direct from the furnace to the tube-front smokebox. Look out for this defect, for sometimes exceptional neglect permits a dry sheet to burn even into the rivets which hold the head of the boiler.

Questions 17 to 19 may be treated in much the same manner that the leaky seams and the leaky tube ends were treated. Find where and how much weakness exists, and then deduct from the 100 per cent. of plate efficiency, and whenever that reduction of efficiency falls below the 86 per cent. of joint efficiency, then it must be brought up as a reduction of safe working pressure. But as a reduction of efficiency has already been brought about, say to 78 per cent., by trouble with the tube ends, then the matter of leaky seams or rivets will have a longer range—not from 100 to 86, but from 100 per cent. down to the 78 per cent. already found for the other defects. It is well carefully to tabulate all these defects, in order that no possible error be made when repairs are effected, for even if the shell plates had been found so defective as to bring the efficiency down to 80 per cent., this finding would not lower the rating of 78 per cent. already found on the tubes, but when the tubes are repaired then the rating of 80 per cent. for defective plates comes into force, and that percentage of the plate strength is all that can be given until repairs are made to the defective plates also. Then the next highest percentage prevails in turn. If they are all tabulated, it will be easy to determine just what repairs must be made in order to bring the percentage up to a profitable point.

Bags and Bulged Plates

Questions 23 and 25 deal with defects usually caused by a deposit of dirt on the fire sheets, and unless there are very evident signs of distress, it is better to run the boiler with the bulged plates instead of cutting out the baggy piece and putting on a patch. Such repair causes a square-edge pocket which it is hard to keep clean. When it is necessary to patch a bulge in order to keep the safe working pressure up to standard, then cut out so large a portion of the defective sheet that the new joints will come out of the reach of the fire. In other words, put in a full width of sheet and length enough to avoid pockets. The usual failure of bulged plates is by cracking, and they should be carefully watched to discover such a defect the instant it takes place, for once the bulged plate develops a crack the inspector must cut the pressure away down toward the bottom.

Expansion of Boiler Rearward

Questions 26 and 28 should be carefully answered and attention in this direction will prevent the very annoying and sometimes serious accident of having pipes break off at their intersection with the boiler. A blowoff pipe breaking off when the power load is full, causes very uncomfortable proceedings in the boiler room. See that the manhole frames are of types approved by insurance companies and give pressed steel the preference as noted by questions 29 and 30. Regarding questions 31 and 32, the back arch should be placed low enough to prevent any of the plate in the back head over the steam space from being exposed to flame or hot gases passing through the tubes. The back arch should nevertheless be high enough so that it does not cover any of the tube opening. Care should also be taken by the inspector to see that the back arch is free to let the boiler go and come during heat changes. Sometimes the back arch becomes fixed against the boiler, and prevents the boiler from expanding rearward. As a result, in certain instances the boiler front has been torn loose from its bolts and the water-column connecting pipes broken off. The boiler should at all times be free of the arch so that the expansion of the shell may take place toward the rear end of the shell.

In regard to questions 33 to 36, the boiler usually comes with the lugs properly located and fastened. Some boilers, however, are equipped with lugs made in two pieces, one piece being riveted to the shell, the other piece slipped on. Sometimes these pieces will slide over each other and the motion of expansion will be taken up at the front instead of the back end of the boiler. In cases like this, the inspector will see that the front lug members are so tightly wedged with steel wedges that there can be no movement between them to disarrange the water-column pipe connections.

The inspector should also see how the top of boiler is covered. If with brick, the covering should take the form of an arch, for it is not desirable to have several tons weight of brick resting on the boiler. The side walls should also be built out to touch the boiler at or below the water line to prevent the overheating of shell plates not backed up by water.

Gage Cocks

Questions 37 to 39 should receive very close attention by the inspector. It is necessary that the boiler be fitted with three gage cocks, also that said cocks be correctly located as to hight. If they are too high, the steam space is made too small. If the cocks are placed too low, there is danger of the upper row of tubes becoming uncovered and burned or made

to leak. Gage cocks are no longer made independent and each piped separately into the boiler. See that a well designed combination water column is used with both gage cocks and a water-line glass attached thereto. See that the bottom of the glass and the lowest gage cock are both above the top of the upper row of tubes. See that the water column fits the boiler. A column designed for a 72-inch diameter boiler placed in front of a 48-inch shell, cannot be located satisfactorily as to the hight of all the gage cocks. The answers to the three questions will fix the location of the cocks and glass.

Steam Gage and Safety Valve

The matter of the steam gage will be settled by the answers to questions 40 to 45, and the disposition of the gage and its connecting pipes should be in accordance with paragraphs in the first portion of this article. The safety valve should not be attached to any supply or distribution pipe. A separate opening should be provided into each and every boiler and the safety valve attached thereto without the intervention of either valves or more pipe than are necessary to make the connection. Questions 44 to 47 carry full data in their answers for properly understanding the safety-valve situation. The safety valve should be tested if possible, by getting up steam in the boiler and noting the pressure at which the valve blows off. The safety valve and the newly adjusted steam gage should indicate the same blowing-off pressure, thus forming a check upon each other.

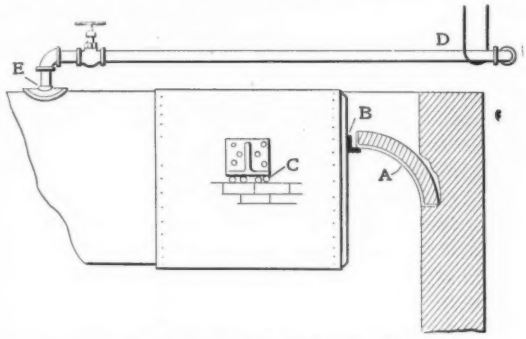


FIG. 9. BACK ARCH AND MAIN STEAM PIPE SUPPORT

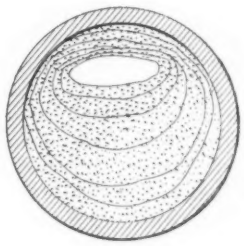


FIG. 10. SCALE-OBSTRUCTED FEED PIPE

Support the Steam Pipe

Question 48 is sometimes a very important one. If 20 feet or so of steam pipe be unsupported except by the connection with the boiler and a pipe hanger at the extreme end of the pipe, severe strains are likely to be put upon the flanged or screwed connection of pipe with boiler. Fig. 9 shows how this may happen. The pipe *D* is unsupported except at the extreme ends, and any vibration of the pipe up and down or sidewise can only result in exerting a severe strain upon the connection at *E*. Should the pipe happen to fill with water, a much greater strain will be imposed upon the connection at *E*, hence it stands the inspector to see to it that steam pipes which are connected with the boiler are well supported close enough to the boiler to remove all dangerous and unnecessary strains from the connections with the boiler.

Question 49 was formerly a very important one, as boilers were frequently found with pipes rigidly connected between tees placed close to, and directly above the openings or necks. Pipefitters have nearly all been educated to the necessity of connecting boilers through a long pipe free to swing sidewise, with its own expansion and with that of the boiler without placing undue strain upon the connections, hence this question is not generally very important as boilers are now connected up. Still the inspector should keep an eye out for such things—and for everything else which can affect the safety of the steam plant.

Back Arch Construction

Question 50 is a vital one, and severe accidents have been caused by neglect of this matter. One form of back arch is shown at *A*, and one of the rear lugs with its plate and rolls at *C*. All the travel of the boiler shell, due to expansion and contraction, should be upon these rollers and the back arch should be so constructed that there is play enough at *B* to allow free movement of the boiler. Sometimes sufficient care is not taken in this direction and a solid bearing is formed at *B*. When the boiler shell expands, something must yield, and as the shell is anchored solidly against the heavy rear wall, and as the front wall is very light and has little bearing against the boiler, the friction of the front lugs is overcome and the boiler slides forward to the great discouragement of the boiler setting, the front casting and the feed-pipe and water-column connections, which are sometimes broken off by the forward movement of the boiler.

External Corrosion

Questions 52 and 53 relate to a matter which may cause serious trouble. Water leaking upon the covering of a boiler and finding its way to the shell for a considerable period of time, may cause corrosion which will eat a hole entirely through the shell. The inspector should look closely for anything of this kind, and any corroded spots which exist should be carefully cleaned, and if of any extent the thickness of the remaining plate carefully ascertained. Drilling is not necessary in cases of this kind, as the depth of corrosion can be closely determined, after the shell has been cleaned, by means of a straightedge and a scale. Apply the red-lead treatment to all such cases and thoroughly shingle the boiler.

Blowoff and Feed-pipe Connections

Question 54 should be studied in connection with question 28. The blowoff pipe should always be taken from the lowest portion of the shell. Every horizontal tubular boiler should be set with the rear end at least 1 inch lower than the front; then it is logical that the blow-off pipe should be tapped out of the back end of the shell.

Regarding questions 54 to 58, the feed pipe may enter the boiler almost anywhere, but the best place is through the front head just above the tubes and between the shell and the outermost tube. The internal connections vary all the way from nothing at all, to all manner of heating pipes, perforated sprinkler pipes, scale-depositing pans, etc. The best arrangement of internal feed-pipe connections is that known as "The Hartford," consisting of a plain pipe extending back from the front to a point just in front of the rear head braces, an elbow and a pipe extending across the steam space above the tubes and terminating in another plain elbow which discharges forward between the shell and outer tube, but so arranged that the feed water touches neither shell nor tubes as it falls from the feed pipe.

There should always be a heater used in connection with a steam boiler even when no engine is used, for there usually is some way by which waste steam may be supplied to the heater. Still the inspector cannot condemn any practice which dispenses with the heater, but in such cases he should take particular care to ascertain if the stream of feed water has been impinging upon the shell or tubes, and if such be found to be the case, extra vigilance is necessary to detect incipient cracks in the metal against which the cold water has been allowed to flow.

Braces

Questions 59 to 69 should be carefully answered by the inspector, for the safety of any boiler depends largely upon the condition of the braces and the manner in which they are attached to and distributed over the heads. Upon crawling into a boiler, the first thing the inspector does is to look at the opening leading to the safety valve and see if that opening is clear. He will also look at any other openings that may be within sight and note their condition. Next, he is apt to

look at the condition of the shell and tubes as regards scale and other deposits. If there be any scale or mud, he picks a hole in it with his hammer and determines the character and thickness of the deposit and is thus prepared for questions 74 and 75. The inspector will bring up at one end of the boiler soon after he enters the shell, and then the rattle of his hammer against the braces will be heard. He hits them all, one after the other, and his ear tells him if any of the braces are loose, broken or strained tighter than the rest. This gives him the data for answering questions 67 and 68, and then he looks at the head to see how the braces are attached thereto. Sometimes he finds there is a lot of deposited matter, and after digging through it he finds corrosion on the head, braces or on the angles to which heads are attached.

If there be any corrosion found at the junction of the head and braces, it must be treated the same as described for outside corrosion, and the extension and depth carefully traced, measured and noted under questions 70 to 76. The wasting of metal found here goes to influence the rating for safe working pressure, exactly as was the case with outside corrosion. The number of braces will be carefully noted, also their arrangement as regards even distribution over the head surface which is to be supported by the braces. The inspector will calculate the number of square inches of area in the head above the tubes, allowing a strip 3 inches wide all around the outside of the head to be supported by the flange which is riveted to the shell. Likewise, a strip 3 inches wide above the top row of tubes will be considered as supported by the tubes. The remaining area, multiplied by the pressure carried, will give the load to be carried by the bracing. No more than 6000 pounds to the square inch of brace section should be allowed for a brace load, and where the braces are made of 1-inch round iron or steel, 5000 pounds is the proper load to be given each brace of that diameter. In this manner the number of braces necessary may be determined. The manner in which the braces are distributed should be noted, for it is not desirable to have two rows of braces close together and then a wide space between. This answers questions 65 and 66, and 59 will be answered also.

Question 62 must be given careful attention. There should be no brace in any boiler less than 30 inches in length. A shorter brace brings too great an angle in the brace and loads the brace beyond its capacity. Question 63 will now be found answerable, and it is preferable that steel-plate braces be used and attached to the head by means of angles which permit of a direct pull upon each brace without the intervention of a crowfoot or any other forged contrivance where they are attached to the head.

Wasting of the brace rivets should also be carefully looked after, for the inspector sometimes finds braces entirely loose at one end through wasting away of the rivets. The number of braces below the tubes in the front end differs from the number in the back end of the boiler when there is a manhole in the front end below the tubes. There may be two through braces, or there may be several braces as above the tubes. The through braces or stays, if there be any, should be calculated to the diameter at the bottom of the thread, and if they are upset at the ends, see that the main portions of the rods are as large as the diameter at the bottom of the thread.

Question 60 will require a visit to the rear head ere the answer is forthcoming, and the arrangement of braces is sometimes different at that head than at the front end of the boiler. This is particularly the case when there is a manhole in the front head below the tubes, and only a handhole in the rear head below the tubes. Sometimes there is not even a handhole at the back end of the boiler and the inspector must examine things there as best he can by means of a torch on the end of a long rod. The flue-scraper handle will do. Just tie on a rag or a bit of waste, saturate it with kerosene oil (a little gasolene mixed with the oil makes a quicker and better light), touch it with a lighted match and push the burning mass to the back end of the shell. Every bit of shell, head and brace surface will be easily seen in the bright light made by the torch. If there are braces below the tubes at the back end, sound them by rapping them with a short rod let down through the spaces between the tubes from above.

Oil Deposits

Questions 70 and 71 seem almost directly opposed to each other, yet both kinds of trouble are found in boilers, and in one case things will be found like *A* and *C* in Fig. 8, while in another boiler it will be found that corrosion has made the head resemble *B* and *D* in the same illustration. Sometimes there will be found a simple deposit of grease over a good part of the heads and shell; in other cases only along the water line. Oil deposits of this character, while not desirable by any means, are not particularly dangerous—at least until they become thick enough to keep water from the plates and cause overheating. Deposits of oil are more frequent on the front head, because the heat there is less at the water line than at the rear head. The attention of the owner should be called to deposits of oil and means taken to prevent access of grease to the boiler.

Scale Deposits and Corrosion

Scale deposits are far more common, more dangerous and more to be feared than deposits of oil. The inspector may find the space between the tubes completely filled with deposits of scale or mud. The coal pile feels the effect of this badly, and the shell and tubes suffer from overheating to such an extent that after the scale has been removed the tubes will be found loose from the intense heat to which they have been subjected without a water backing to carry off the heat as fast as received.

Sometimes the inspector will find the plates pitted. Innumerable rust spots are found, and upon being picked there is found a hole under each spot of rust. Sometimes instead of pits there is a long corroded streak from which the metal has been eaten away, and sometimes it looks as if the metal had been grooved out with a round-pointed chisel. These things go to decrease the strength of the boiler, and if the causes are still active, that is, if corrosion is still eating away the metal, then the inspector must be very careful indeed about the pressure rating he gives the boilers. If such conditions exist, the owner should be made aware of the fact and immediate steps taken to stop and to prevent any further action. Otherwise, the boiler will be quickly ruined and the working pressure must be cut down as the destruction progresses. The inspector should never pass a lump on the plate or tube without getting into it with his little sharp-nosed hammer, for sometimes the corrosion goes so deep that when it is removed the hammer can be driven right through the remainder of the shell thickness. This has been done in the course of regular insurance inspecting, and in one instance at least the owner of the boiler sent in a bill to the insurance company, claiming that the inspector broke the boiler. It may be added that the particular case of corrosion referred to was caused by the constant dropping of water from a leaky water pipe which crossed above the boiler about amidships. The water dripped upon the brick covering and ran down upon the shell. It was discovered by the merest chance. The inspector had looked over everything inside the boiler and was lying on his back just below the manhole preparatory to coming out. He was just ready to blow out his candle when he noticed a slightly discolored spot on the shell, just above the water line. Here the habit of the inspector of hitting with his hammer everything which looked suspicious, came into play, and he struck the discolored spot a smart blow and found a false note in the ring of the metal. Investigation showed that a mass of rust had formed outside the shell, and after the bricks were removed and the rust had been thoroughly cleaned out, there was a hole 3 inches long and 1 inch wide entirely through the shell.

This is an excellent example of the ceaseless vigilance necessary on the part of the boiler inspector. He must see everything, test everything and take

chances on nothing whatever. Neither eye nor ear alone should be depended upon, but both senses should be used and close scrutiny should supplement the hammer blow in testing each and every bit of metal in the boiler. Only in this way can the inspector be sure that he has obtained the necessary knowledge of what is taking place in and about the boilers he inspects.

And before inspecting any boiler the inspector should if possible carefully read and study the reports of previous inspections. This will act as a guide in the direction of any known imperfection of the boiler, but it should not serve to lessen the alertness of the inspector. It should make him all the more alert to discover hidden imperfections as well as to keep close watch upon those already known. The fact that a certain boiler is actually imperfect in some part should render the inspector all the more cautious to discover the presence of other defects which may be present, but as yet undiscovered.

Tube Inspection

While the inspector is in the boiler on top of the tubes, he should look carefully for signs of pitting of the tubes. Sometimes the tubes are attacked and little rust spots show themselves as smooth, round bunches, which, when opened, are found to cover little pits which will continue to grow deeper until they eventually extend entirely through the tube walls. Sometimes the inspector will find both shell and tubes affected in this manner. Sometimes the tubes will be affected and the heads and shell will be clean. Sometimes the tubes are clean and the heads or shell, or both, are affected. No matter which is affected, the corrosion must be noted and means taken by the owner to cure and to prevent it. Sometimes a feed-water purifier will do the business, or a compound selected by a chemist after an analysis of the feed water prevents further action. Again, the action will continue in spite of everything until a new set of tubes is put in, when action may cease, or it may not. Cases of this kind have been cured by placing a lot of zinc inside the boiler. The action ceases as long as the zinc lasts, that metal being eventually converted to an oxide by electrolytic action or otherwise.

While looking over matters at the back end of the boiler, the inspector should examine the internal feed pipe closely. The pipe should be suspended by stout wires from the braces and not allowed to rest upon or across the tubes, which have been known to cut through by the continual movement of a feed pipe upon them, the movement being caused by the pulsating of the feed pump. The feed pump should also be closely examined to see that it is not choked by scale deposit. A few blows of the hammer along the length of pipe quickly reveal the condition of things inside, for the sound of the scale-choked pipe is very evident. Fig. 10 closely resembles the appearance of a section of pipe discovered by the writer when inspecting a boiler. While this is not a dangerous condition of affairs, it is a decidedly inconvenient one which caused a good deal of trouble, the mill having closed down twice on account of the failure of the feed pump to supply the boiler with water.

Defective Rivets

Question 76 has been discussed by several of the preceding paragraphs and the inspector will understand now how to take care of this point. Questions 77 and 78 should be closely looked after. Indications of broken rivets are usually in the form of persistent local leaks adjacent to the defective rivets, and all such cases should be carefully sought for and found by the inspector, and repaired at once by the owner. Such defects are dangerous from two causes: from the weakening of the seam which may cause adjacent rivets to be overloaded and shear off, and dangerous from the corrosion which may be caused by water from the boiler continually sweeping through the seam beside the defective rivets. A reduction of rivet percentage must be given when defective rivets are found, and a generous reduction it should always be.

Loose Scale and Mud and Burned Plates

Questions 79 and 80 refer to occurrences which, though not dangerous in themselves, nevertheless may lead to dangerous things. By a collection of mud, loose scale and other foreign matter upon or over the fire sheets of a boiler, serious overheating of plates may take place through caking of the mud, thereby preventing access of water to the hot plates. Many of the unsightly and even dangerous bulges found over the furnace sheets of boilers may be traced directly to a collection of caked mud. When the sheet bags down, the caked mud is broken up and dispersed by the first water which reaches the red-hot metal. The inspector cannot give as high a working-pressure rating when he finds evidence of chronic presence of mud and loose deposits in a boiler.

Question 81 relates to plates which have been exposed to hot gases without a water backing behind the plates in question. Therefore, the inspector should look closely for such defects along the water line of the shell and back head. There is little chance of such overheating taking place at the front end unless the entire upper row of tubes goes dry, but the back head, especially where the arch is defective or too high, should be closely examined for incipient cracks. Good boiler plate will not crack under such treatment unless it is often repeated, but unfortunately all boilers are not made of the best material, hence the great necessity for caution and eternal vigilance on the part of the inspector.

Test of a "Wing" Blower

Following is a report on an 8-hour test of a "Wing" steam-turbine blower on a 200-horsepower Heine boiler, with stack 285 feet high:

Diameter of blower, 16 inches.

Coal used in boiler, No. 2 buckwheat, 7051 pounds.

Percentage of ash and refuse in dry coal, 17.2.

Weight of combustible, 6140 pounds.

Calorific value of dry coal, per pound, 13,490.

Calorific value of combustible, per pound, 12,140.

Weight of water evaporated, "based on combustible," 58,000 pounds.

Factor of evaporation, 1.0385.

Equivalent evaporation of water per pound of coal from and at 212 degrees Fahrenheit, 8.11.

Equivalent evaporation from and at 212 degrees Fahrenheit, per pound of dry coal, 8.67.

Steam used by fan blower, 1313 pounds.

Absolute boiler pressure at fan, 114 pounds.

Velocity of air in feet per minute, 1910.

Quantity of air supplied by fan blower, 103,900 pounds.

Theoretical quantity of air needed, 68,700 pounds.

Ratio of air supplied to theoretical, 151.3 per cent.

Revolutions of fan blower per minute, 3114.

Cubic feet of air delivered per revolution, 1.588.

Cubic feet of air delivered per pound of steam used by blower, 1197.

Per cent. of steam used by fan blower as evaporated by boiler, 2.265.

Boiler horsepower developed and used, 218.

The weather on the day of this test was sultry and heavy. The ash drawn from the fires at the end of the test was found to be fine and pebbly, thus showing that the hot, moist air from the blower disintegrated the ash. The flue-gas temperature was also lower than under natural-draft conditions, showing that there was better absorption of the heat with the forced draft.

The school department of New Bedford, Mass., has instituted free evening industrial and business courses, the former under direction of Charles R. Allen. These courses include lectures and laboratory work in electricity, steam, chemistry, gas engines, etc. The public-school buildings are utilized. The expense is borne in part by the State.

An Interesting Installation

By F. L. Johnson

As I sat at my desk looking at a pile of letters of inquiry from all parts of the United States and Canada, and wondering why men who really want information forget to sign their letters or else leave off their postoffice address, the office boy ushered in my young friend Sawyer. Taking the proffered chair, he said:

"I cannot stop long today; I just ran in to show you a photo of a little device I saw up in Massachusetts the other day, and as it struck me at first it looked pretty good.

"In a central station all of the exciters except one are motor-driven. The odd one is driven by a 100-horsepower non-condensing turbine and is used only in cases of emergency, when a steam-driven exciter is an absolute necessity. This device consists, as you will see from the photograph, of a balanced throttle valve cut into the steam pipe. There is a lead weight fastened to the valve spindle and an electromagnet to hold the valve closed. The magnet winding was energized from the exciter circuit in series with a dead resistance which was so proportioned that a slight drop in potential would so weaken the magnet that the lead weight would drop and pull the valve open instantly. The engineer showed me how it worked by short-circuiting the magnet winding across the binding screws. The weight came down on the run and the turbine was up to full speed in about ten seconds. Then he showed me that the turbine was kept hot all the time by a bypass of ⅛-inch pipe around the valve, with the flow of steam regulated by a needle valve. Believing that the buckets and intermediates were made of steel, I asked the engineer if the condensation of the steam used for heating would not affect the buckets and intermediates.

"'Of course,' he said. 'It will eat them all away in time. But as the builders are replacing all the steel buckets they have made, as fast as possible, I know they will come here some time, and even if they would not, the certainty of having something that will provide against the failure of an exciter is worth something.'

"Having nothing to hurry me away, I asked if he had anything else that was new.

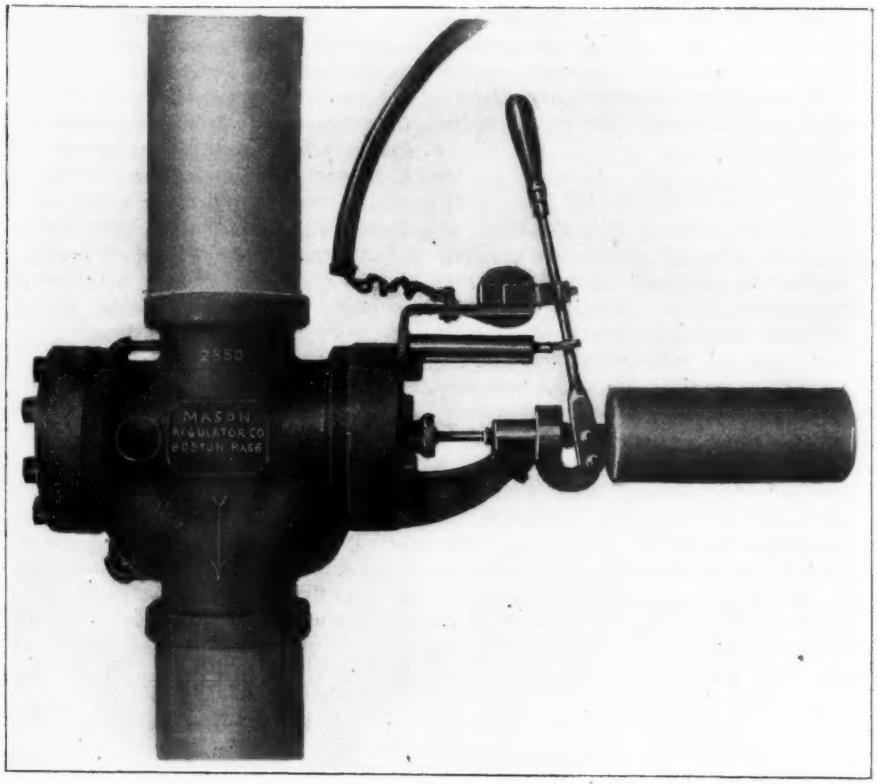
"'Yes,' he said, 'we have several things that are out of the regular practice. That turbine has a cast-iron sleeve on the lower guide bearing. The machine was installed with a bronze sleeve running in a babbitted shell; as the machine ran the bronze sleeve would wipe off a film of babbitt from the shell, and as time went on this film which stuck to the sleeve would grow thicker and thicker until some morning the machine would refuse to start, because the sleeve and its shell had soldered themselves together, or, owing to the perverseness of all material things, the shell would become so worn that annoying vibration demanded a new sleeve and shell. After the proper tools for doing the work were designed and made, it used to take two men about two days to take out the worn parts and put in new ones, and the machine was ready for service for another three months.

"'The chief has always contended that making the rubbing parts of machinery of such metals as could possibly be soldered together was wrong in principle and horrible in practice. He insisted that the sleeve on the end of the shaft should be made of cast iron, and that if so made it would run indefinitely and show no signs of wear. His attempts to get a cast-iron sleeve for this machine met with all sorts of opposition from the engineering department of the turbine builders, but he was persistent and pestiferous to such an extent that the cast-iron sleeve was finally furnished to keep him quiet. The cast-iron sleeve was put on the shaft and for two years it has given perfect satisfaction, showing at the end of the first year absolutely no signs of wear, while three months was as long as a bronze sleeve could be expected to run.

"'Then, there is another thing that is a little funny. We have always been somewhat thick about step pressures and bafflers. There is that machine that ran on a step pressure of from 375 to 400 pounds. The engineers of the building company insisted that the pressure was too low by about 50 pounds, and sent an expert operator from the factory to increase the pressure. It was not just clear why, if 400 pounds pressure would float the machine, more pressure was needed, nor how this increase of pressure could go without altering the area of the supporting surfaces. We were soon shown; the expert ordered the machine run at about half speed; then, with watch in hand, he shut the step water entirely off for 15 seconds; then, seeing that the step pressure had not appreciably increased, he shut it off again for 25 seconds and again for 35. This time the pressure went to 425 pounds.

"'The clearances were corrected and the man went away. He had roughened the surfaces of the step blocks so that the water met with a little more resistance in passing between them. It did not require any higher pressure to support the machine. The water had harder work to get out, that was all. I said we were dense about these things because we do not see any sense in getting up a pressure just for the sake of letting it down.

"'And then about the baffle: Every explanation of its working, of its utility, or necessity only makes us denser; in fact, we are appallingly stupid in the matter and our own experience aggravates our stupidity. For some reason, the man who erected that turbine took the worm out of the baffle and forgot to replace it. The machine ran for months and nobody knew that one of its vital organs, instead of doing its duty by obstructing the flow of water to the step bearing, was slowly gathering rust in one of the pocket holes



BALANCED THROTTLE VALVE IN STEAM PIPE

of the foundation, and it is doubtful if the behavior of the machine would ever lead to the discovery of its absence. An operator from the works started the machine, operated it for several days and then left, saying that it was as fine-running a turbine as he ever handled. The missing baffle worm was found months afterward while repairing some piping that ran near the foundation.'

"There are several other little things about that plant I noticed that I am going to tell you about some time. But before I forget it, I am going to show you some compression and noncompression indicator diagrams that I picked up along the North Shore a few weeks ago."

Then, looking at his watch, he said: "It is later than I thought, and as I promised to lunch with the man who expects to sell me some incubators for my new place, I will have to leave you, but I will run in with those diagrams before I leave the city."

Softly whistling "Hold the Fort," he betook himself to the elevator.

Electric Tunneling

The use of a tiny gas flame or a platinum point heated to incandescence by a circuit has long been used to engrave glass by the decrepitation of small pieces, and this property may be used to a more practicable extent and on a larger scale in rock cutting in tunnels and mining.

A series of electric arcs on a turret at the heading is proposed for the purpose.

The first attempt to pierce Hoosac mountain in northwestern Massachusetts was by means of a gigantic turret carrying numerous chisels, the invention of Gen. Herman Haupt, but, after boring a hundred feet or so, the machine was abandoned and the 4.71 miles of tunnel made by drilling and blasting.

It was a long time before this tunnel was lighted by electricity, as there was not at the time any insulated wire in the market which would resist the dampness of the tunnel.—*Electrical Review.*

The idea of the steam turbine, said W. L. R. Emmett, of the steam-turbine department of the General Electric Company, recently, before the Schenectady section of the American Institute of Electrical Engineers, is a very obvious one, and naturally appeals to everybody. It is the simplest form of production of motion from pressure, and was used by the ancients. The whole difficulty has lain in the fact that the velocities to be dealt with were so high. Steam carries so much power and weighs so little that it attains an enormous velocity when its work is turned into motion. In working steam of 175 pounds gage down to 28 inches vacuum, it will impart to itself a velocity of about 4100 feet per second.

Smoke

This is the title of a paper recently read at a meeting of the Association of Engineers-in-Charge (English) by J. Swinburne, the newly elected president of the association. Smoke, he said, was popularly supposed to be fine particles of carbon, but was more accurately described as tar or pitch. If the pipes leading from gas retorts were opened, there issued large volumes of dense yellowish smoke, consisting of fine globules of liquid tar floating in gas and tar vapor. If these globules were left in a hot atmosphere for some time, the volatile hydrocarbons evaporated off, leaving tiny globules of a sort of pitch. These particles may get burned before they are reduced to pure carbon, or sometimes a kind of grit is produced.

Another form of smoke is that obtained when a flame is allowed to play on a cool surface. This is really floating lampblack, which differs a good deal from tar smoke. When cold bituminous fuel is thrown on the top of hot carbon burning on the fire bars of a furnace, it is heated from below, and the volatile constituents are distilled off. These gases coming through the fire are cooled by the green coal, resulting in large volumes of gas, full of tar smoke, being carried forward. To burn this smoke the only thing to do is to raise the whole of the gas-containing tar to such a high temperature as to insure complete combustion. It did not appear, at first sight, easy to raise the smoke to a high temperature, but it was not impossible. The gases from hand-fed fires were generally led straight to iron surfaces cooled by the water of the boiler, so that the tar had no chance of getting burned. If the fire were itself in a firebrick chamber, and the gases had to pass over a reasonable amount of white-hot firebrick before any attempt was made to abstract the heat, it is quite possible there would be no smoke even with hand stoking. He believed the general principle in furnaces of abstracting heat from the fire and gases at the earliest possible moment was entirely wrong. He suggested that the proper way was to leave the gases as long as possible before beginning to cool them, and not to heat the boiler shell or tubes by direct action of the fire or even by radiation from it. No heat should be taken from the fire or from the gases until all the smoke was completely burned. This would involve rather an elaborate construction of firebrick, probably something like a regenerator, which would get white hot between each stoking.

Mechanical stoking had the advantage over hand firing in that it could go on continuously without interfering with the draft. In the movable fire-bar system the tar and gases get heated to a certain temperature at the front of the fire, where they are under a fireclay arch, but just behind this they burn with a large flame. This flame would most likely burn the tar completely and give no smoke if it had a chance, but it sometimes touches the boiler and causes lampblack smoke.

In the mechanical-stoker system, in which the coal is fed upward, the idea was that the tar must pass through a layer of white-hot carbon, which would decompose it completely, and if there was enough air it would consume the tar. If the air was insufficient it would decompose the tar into light hydrocarbons or hydrogen and carbon, the carbon being deposited on the hot, solid surfaces and being burned subsequently. One difficulty in this system was that air could not be readily admitted through the coal that is being fed. He understood, however, that these furnaces worked well.

The boilermaker seemed to have a fixed idea that the fire ought to be inside the boiler, and the water ought to be as close to the fire as possible. In reality, the fuel was too close to its work. The idea that the best way to heat anything was to put it right into a flame was very widespread. The bunsen burner, the table and laboratory spirit lamp, and gas stoves were familiar examples. The gas engineer has at last found out this simple thing, that the burner must not play on the saucepan. The products of incomplete combustion coming into a room as the result of burners playing on lumps of clay or asbestos were far worse than the products from the same amount of gas burned by bunsen or bat's-wing burners. In boilers there is no reason why the furnace should not be outside in the form of a firebrick structure in which is allowed ample room for the hydrocarbons and air to mix thoroughly, and time for the combustion to be complete. In the case of water-tube boilers, all the furnace makers want is enough room below them, so that the tubes cannot begin to abstract heat until the mixture of the gases and air and the combustion are quite complete.

The subject of domestic fires was then dealt with, the speaker mentioning coalite as an obvious cure for smoke, but not universally applicable. The latter part of the address dealt with the observation of smoke from factory chimneys, the speaker describing a photographic method he had himself devised for reducing to a minimum the errors of observation by different individuals.—*The Engineer.*

Official tests of the sewage-pumping engines at the Thirty-ninth street station at Chicago, Ill., show a consumption of 11.2 pounds of saturated steam of 170 gage pressure per horsepower-hour and an official duty of 150,681,634.46 foot-pounds per 1000 pounds of steam on the north engine and 10.81 pounds of steam per indicated horsepower-hour, and 145,347,847.7 foot-pounds per 1000 pounds of steam on the south engine.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Pipe Supports

In Fig. 1 is shown an anchor for a steam line used in a large power plant of recent construction, the anchorage being to a plate girder near which the pipe is hung. The two anchor rods are made very long, to lessen the tendency to pull the girder sidewise. A bracket for supporting cold-water piping along the basement wall is shown in Fig. 2. The sliding blocks afford adjustment for lining up with the pipe, both horizontally and vertically. In the case shown, the bracket was attached to the concrete foundation with 7/8-inch expansion bolts, and was made very long between bolt centers, to avoid putting an excessive tension upon the upper bolts. This style of support can be used for piping only where expansion strains need not be considered.

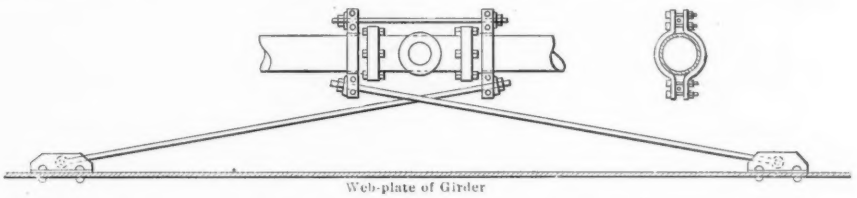
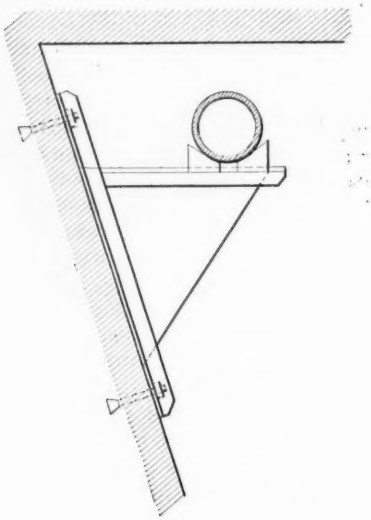


FIG. 1. ANCHOR FOR STEAM LINE



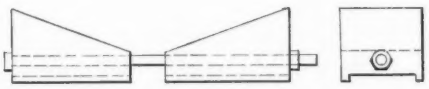


FIG. 2. BRACKET TO SUPPORT COLD-WATER PIPING

Fig. 3 shows a type of hanger for the steam line where it is possible to attach to the wall at a much higher point, allowing the hanger to swing freely as the pipe expands and contracts, the hanger being so long that the slight tendency to pull the pipe in a horizontal direction may be neglected.

A very satisfactory support for a vertical exhaust pipe is shown in Fig. 4, the connection being made to the web of the floor beam. The forgings are of very simple form and easy to make; the band is made loose to permit expansion of the pipe.

The springs shown in Fig. 5 are used when a pipe has numerous vertical connections, the expansion of which tends to lift it from the hangers. The springs should be of a length suitable to suffer a reasonable amount of deflection without a greatly increased resistance.

Clamps for gripping the lower flange of an I-beam are frequently to be seen shaped as in Fig. 6. A much stronger form is shown in Fig. 7. This clamp will not readily break. The angle *A* need not be greater than 45 or 50 degrees, which will combine sufficient strength with the necessary stiffness.

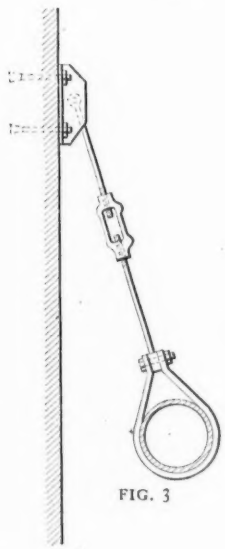


FIG. 3

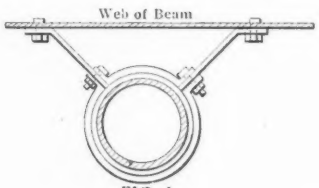


FIG. 4

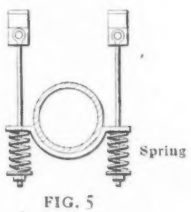


FIG. 5

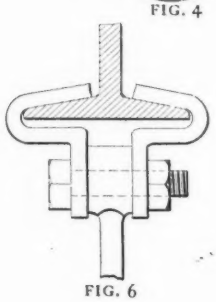


FIG. 6

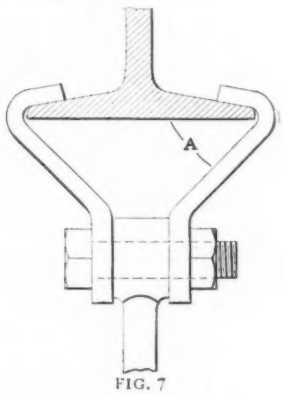


FIG. 7

GERALD E. FLANAGAN.

Pittsburg, Penn.

Vibrating Boilers

In the October 27 number, Richard Owen tells about his vibrating boilers, and the different pipe connections he made to overcome the trouble, but without getting satisfaction.

In my opinion, the engine is too big for the boilers. This is especially true of a Corliss engine with quick opening and closing valves. The pressure in the 6-inch pipe line near the engine is reduced at every opening and closing of the valves, which causes vibration of the boilers.

I would suggest that he bring the 12-inch header as close to the engine cylinder as possible, or, better still, use a larger one, or a separator of ample size, and place it near the throttle. This would serve as a storage tank, thus keeping a constant pressure in the pipe line. The boilers should not vibrate under such an arrangement.

W. STEINDORFF.

Brooklyn, N. Y.

What Wrecked the Engine?

The letter of Edward T. Binns, recently, asking what wrecked the engine, just came to my attention. I think the piston rod worked loose in the crosshead and the piston then struck against the cylinder head.

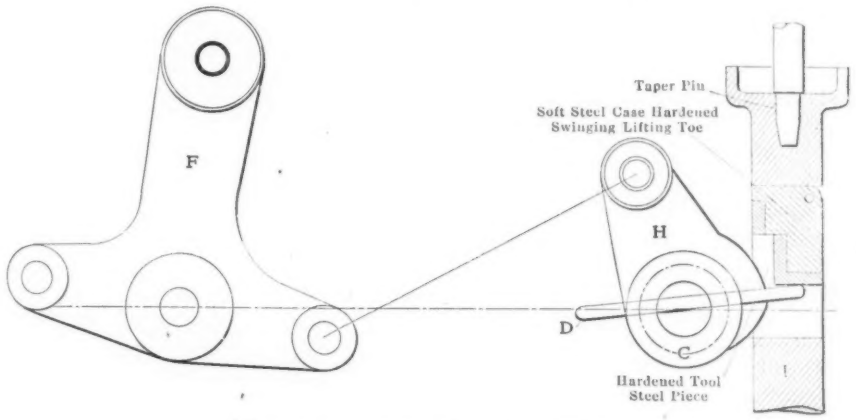
By the time the cylinder head went out, the piston rod had screwed out of the crosshead so far that there were not threads enough to withstand the force of the steam, and consequently the few threads that were holding were stripped. As the nut on the piston rod could not go through the stuffing box it was stripped off as it struck the stuffing box.

P. C. FORGARD.

Lake Preston, S. D.

Setting the Valves of the Wright and Reynolds Engines

Mr. Collins' reply to my letter, on page 623 of the October 13 number, calls for some notice from me. Mr. Collins says that if the valve gear of the Wright engine will not operate as he has shown the lifting yoke *I*, no Corliss gear with a grab hook would operate; but why this is so is not very clear. The reason that "as a general proposition there is no difference in principle in the movement of any release cutoff valve gear" does not prove that his sketch of this yoke is operative. How is the toe *d* in the rocker *H*, in his sketch, going to swing back under the yoke *I*, after the toe *d* has lifted the yoke, and the yoke and valve drop down, unless there is a swing toe in the yoke as shown in the accompanying sketch?



SHOWING THE SWING TOE IN THE YOKE

Further, my letter says the *"valve gear"* on the engine from which the diagrams shown were taken is *"identically the same as Mr. Collins' article treats of."* Quite a different statement from saying the yokes *I* are identically the same as Mr. Collins shows them. Then again, Mr. Collins says: "The assertion that the cutoff is not varied through the medium of the rod *S*, Figs. 11, 12 and 13 of the article referred to, is also erroneous." I must insist I do not make such assertion, and in proof of this refer to my statement at at the bottom of the second column and the top of the third column that: "The action of the governor when the balls revolve in varying horizontal planes varies the cutoff in identically the same way as varying the length of the rod *S* would if the governor balls revolved in a single plane."

Now, as to the question of varying the length of this rod *S* to get an earlier or later cutoff, as Mr. Collins directs in the last paragraph of his article in the July 7 number. At the beginning of this paragraph he says: "Block up the governor to its highest point, and while pulling the engine around one complete revolution, see that the steam valves do not pick up at all," which is correct, not only for the Wright engine, but all release cutoff valve gears. But suppose after having done this correct thing the cutoff is not late enough for some "near expert" and he changes the length of the rod *S* to get a later cutoff? Won't the governor balls rise and bring the cutoff back to where it was to suit the load, and the only thing you have done is to speed up the engine? Moreover, when the whole load is thrown off and the governor balls rise to their highest point, the valves will still pick up and the engine will run away. If you adjust the length of the rod *S*, to get an earlier cutoff, the governor will drop and bring the cutoff back, not exactly where it was, but a little later than it was before, to suit the load, and the only thing you have done is to decrease the speed, because the speed must decrease in order that the balls may drop. As a matter of fact, instead of obtaining an earlier cutoff, you actually get a later cutoff, because the speed has been decreased and a later cutoff must be had to carry the load.

The fact is, after adjusting the valve gear so the valve will not pick up when the governor is in the highest point, the governor takes care of and varies the cutoff to suit the load, and this is true of all engines whether release cutoff, four-valve nonrelease, shifting-eccentric single-valve, or throttling-governor slide valve.

R. A. NIVEN.

Brooklyn, N. Y.

Merits of Safety Devices

Referring to an article in the October 27 issue, by Henry E. Fischer, indorsing what Mr. Ranney said, in a previous issue, anent the danger of safety devices, I would say that Mr. Fischer's experience with automatic feed-water controllers and other safety devices must have been a great disappointment to him. It is very evident that he has yet to enjoy the pleasure of seeing a feed-water controller that will control under all conditions to be met with in the boiler room.

I am in charge of a steam plant where the boilers are all equipped with controllers. Prior to their installation the firemen handled the water as the average fireman will, trying to keep it at as nearly a uniform hight as possible, except when cleaning fires, at which time it was allowed to vary almost the length of the gage glass, not only a wasteful, but also a dangerous procedure. In a plant where the load varies at all, it is almost impossible to keep the water level much nearer than 3 to 5 inches of a uniform hight. In regard to the men being careless of water where controllers are in use, I would say that in the two and one-half years these controllers have been in operation, I have never seen any of the firemen show any tendency to depend upon them to the extent of being careless, for although the variation of water level is less than ½ inch, and the controllers have given practically no trouble since being installed, they are always on the alert for anything that might go wrong in the way of solid matter in the feed-water pipe.

It is safe to say that the danger from a feed-water controller which is not depending on a float, or other destructible device, for its operation, in conjunction with a good pump governor, is practically nothing.

No one should purchase safety devices of any sort, for boiler- or engine-room use, without first ascertaining what the article under consideration is doing for someone else.

In regard to the automatic engine stop which would not work until the engine tender loosened the nuts on the gland of the throttle, while knowing nothing of the conditions prevailing at the plant, I would suggest that the packing on the valve stem was pretty well worn out and the nuts were set up unreasonably tight to prevent leakage, making it impossible for the stop to operate. If this was so, was it the fault of the stop or the engineer?

Feed-water regulators, engine stops and other safety devices, no matter how great their merit, require some attention to keep

them in condition to perform their various operations successfully, some requiring more than others, but there are engineers who imagine that anything in the shape of an automatic appliance should take care of itself, for all time, and when, after months of uninterrupted service, it shows signs of neglect, it is condemned as being "no good."

I say be progressive, get controllers and get engine stops, but be sure and get the kind that will work.

ROBERT P. GUY.

Bennington, N. H.

The Centrifugal Pump

George H. Gibson's article on the above subject, on page 560 of October 6 issue, is very interesting, but he does not prove his contention, namely: "The water within the impeller * * * will be revolving at high speed, but once it has reached this speed it calls for no further power."

His illustration of the idea with the argument about the freight cars is not at all applicable to this case, and if his chart showing the decrease in available head and increase in power consumed by a centrifugal pump when the delivery of water is increased at constant speed is simply plotted to the formula

$$Power = \frac{W V^2}{2 g},$$

how does he know that it will indicate the actual practical working load?

Surely a centrifugal pump running with suction open and discharge closed is operating under a considerable load, for the shape of the impeller is such that it is constantly trying to throw more water into the outer casing, and as this is impossible, then it is forcing its way through the water against the resistance due to the pressure built up in the casing, due to its circumferential velocity.

It is something like a paddle-wheel steamer which has run its bow into some obstruction, and the captain orders full power ahead; the paddle wheels plow through the water, and although the steamer does not move, yet the engines are delivering their utmost power.

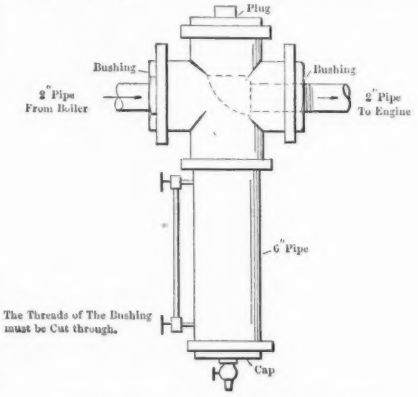
In the centrifugal pump the impeller is working against the maximum resistance, although the water is only churned and is converting the power into heat. It seems to me that Mr. Gibson's argument and chart would be more approximately true if the centrifugal-pump casing were concentric with the axis of revolution instead of an involute, as then the whole mass of contained water would be able to sweep around with the impeller instead of being churned, as is the case with the involute form. I would be very interested to know if Mr. Gibson plotted his chart from a series of actual tests or upon a theoretical formula as mentioned before.

GEORGE P. PEARCE.

Exeter, N. H.

Separator Made of Pipe Fittings

Here is a good way to make a steam separator entirely of pipes and fittings. It consists of one cross, two 6x2-inch bushings, one 6-inch cap, one 2-inch ell and a short nipple. These dimensions are the proper proportions for this combination



SEPARATOR MADE OF PIPE FITTINGS

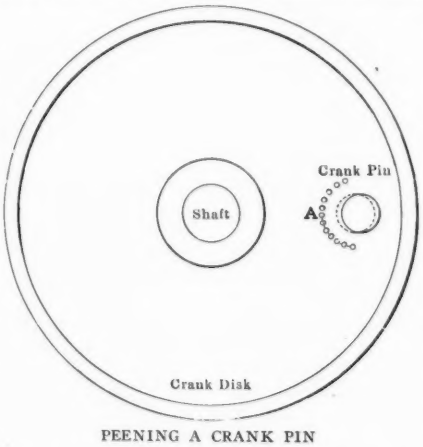
of belting. They may be made larger or smaller. The illustration shows the construction clearly.

G. A. JANICKE.

Louisville, Ky.

Peening a Crank Pin

The following is how we reset the crank pin on a cross-compound engine that had a peculiar pound on the low-pressure side: The crank pin was not true with the shaft, so we peened the cheek of the crank disk about an inch away from the pin, on the side that was inclined in, and in a short time had it true, with the level on all four quarters. I have known this to be done before. The pin was out about as shown by the



PEENING A CRANK PIN

dotted line in the illustration. The peening was done with a drift bar and sledge on the line shown by the small circles *A*.

It does not require very hard blows of the sledge, but one should move the drift after each blow and the level should be used frequently until the pin is true.

H. H. FORNEY.

Barberton, O.

Tightening a Loose Crank Pin

William Longstreet, in the October 13 issue, page 621, shows how he tightened a loose crank pin by driving in four taper pins.

In one of the technical papers published about thirty years ago I described a plan we had just used on a 9-inch Corliss engine shaft when the crank had become loose, which was by drilling and reaming a 2¼-inch taper hole in the center and driving in a taper steel pin. And we have practiced the same thing in a number of smaller shafts since. It is, I believe, a little better than Mr. Longstreet's, as it makes a fit all around rather than at four narrow places.

JOHN E. SWEET.

Syracuse, N. Y.

What Breaks the Field Coil Lugs?

On page 663 of the October 20 issue, Mr. Norman asks what breaks the field-coil lugs on a small direct-current motor. As near as can be judged from the sketch shown the lugs are cast with sharp corners. This results in a weak spot at the angle, due to the internal stresses set up in cooling, and the force required to rupture the lug at this point is only a fraction of what would be required with a properly made lug.

As the motor is started and stopped some 72 times a day, the stress on the lugs, due to the magnetic pull, is applied and relieved the same number of times. Taking into consideration Wohler's law that a material may be broken by repeated applications of a force which would be insufficient to produce rupture by a single application, and the fact that the lugs are weak at the angle, it becomes quite evident that in time the repeated application of the magnetic pull, if of sufficient magnitude, would cause the lugs to break.

As the diameter of the armature is not given, it is impossible to determine the actual magnitude of the magnetic force between the rotor and poles, but it would seem that this force, in itself, is of nearly sufficient magnitude to break the lugs after repeated application, and that the shucking of the lower coils, which necessarily occurs since the magnetic force on the coils and gravity are acting in opposite directions, adds enough extra stress on the lower pole lugs to cause them to break. The lugs on the two upper poles not being subjected to this additional stress, since the magnetic pull on the coils and gravity act in the same direction, are able to withstand the stress due to the magnetic pull alone.

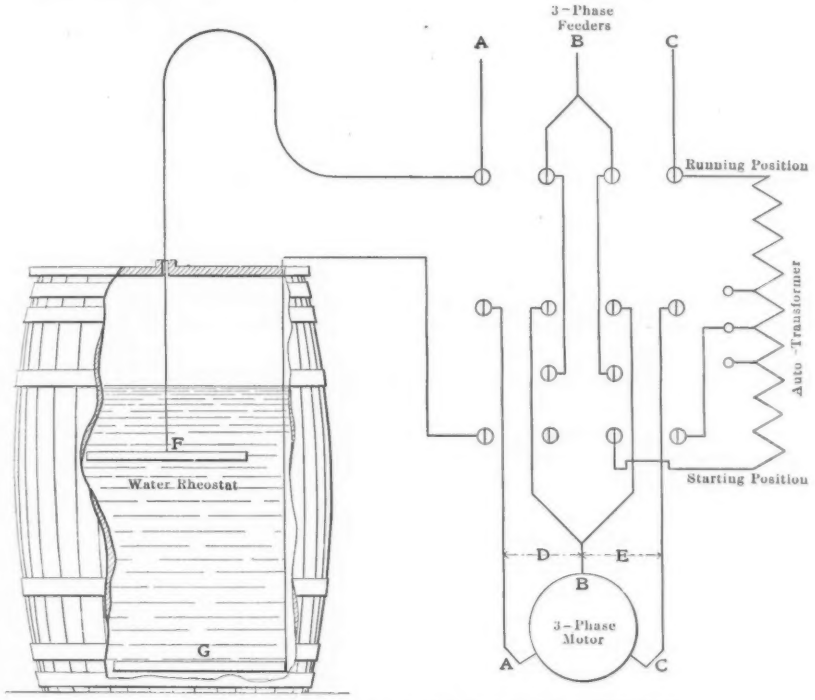
I would advise Mr. Norman either to use a wrought-iron lug which has been annealed after making the angle, or round the corners on the cast-iron lugs so as to relieve all internal stress at that point.

W. L. DURAND.

Brooklyn, N. Y.

Water Rheostat Replaces a Burnt Out Autotransformer

While employed as chief electrician of a large portland-cement plant, one of the autotransformers on a three-phase induction motor was burnt out. As this motor was too large to be started direct from the line, and as it was necessary to have the motor running before we could get another transformer, I used a water rheostat, made out of an oil barrel, connecting it as shown in the sketch herewith.



WATER RHEOSTAT AND AUTOTRANSFORMER CONNECTIONS

The affected autotransformer was on phase *A*, while the one on phase *C* was not damaged. The barrel was filled about three-fourths full of water, and enough salt was added to reduce the resistance. The two plates, *F* and *G*, were of iron, their distance being determined by connecting a voltmeter across phases *B* and *C*, at *E*, and throwing the starting switch to the starting position, when the voltmeter reading was taken. Then we changed the voltmeter to phases *A* and *B*, as at *D*, and adjusted plates *F* and *G* until the voltage was the same. The plate *F* was then fastened in position.

When the motor picks up, the switch is thrown up in the running position, thereby connecting the motor to the line and cutting out the water rheostat.

The motor upon which I used this rheostat was a 100-horsepower machine and had a six-point controller, with the autotransformers mounted on each side of the controller. As the motor would start on the third point of the controller I adjusted the plate *F* to give the proper voltage on that point, and when the motor picked up in speed the controller was put on the running position. This rheostat was in use about ten days before I put in a new transformer.

R. L. MASSMAN.

Fremont, Ohio.

Central Station Service Was Costly

There is no doubt but that the majority of public-building power plants can generate current cheaper than it can be purchased from a central station, and where steam is used for manufacturing and heating the cost is mainly interest on the investment, depreciation, repairs, etc. As an instance of this, I have in mind a small public-service plant, consisting of a return-tubular boiler and an automatic engine for driving the line shafting, steam being used also for heating water, cooking, etc. Motors were installed and current purchased, but the coal bill was just the same as before, with an additional cost of $100 for current.

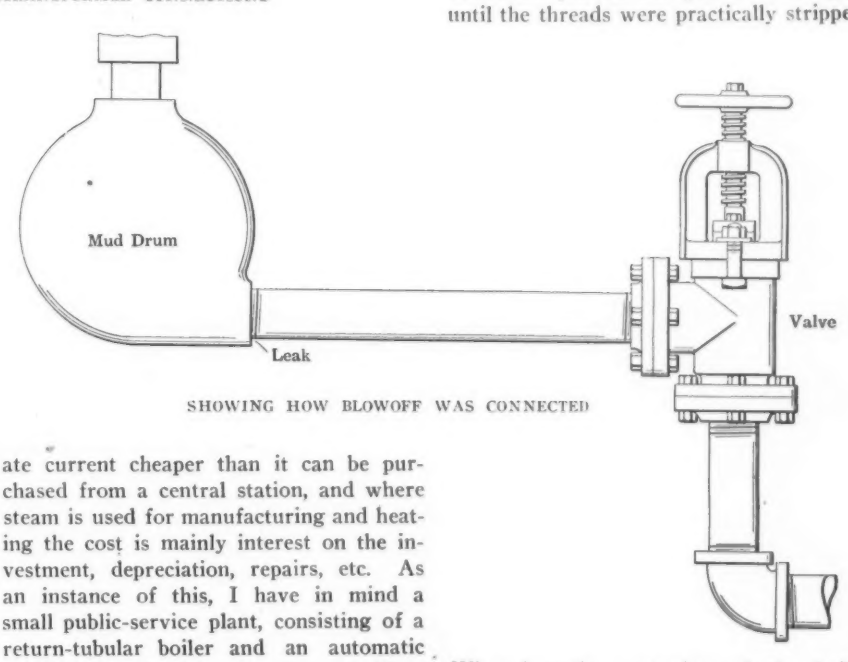
ROY J. RIVERS.

Minneapolis, Minn.

A Blowoff Trouble

Our boiler plant consisted of one water-tube boiler with the blowoff pipe connected centrally in the bottom of the mud drum. One Monday morning the night watchman reported that he could not find any water in the glass. I watched the boiler closely after getting steam up, but the water remained all right and I did not run the pump any faster than usual. The following Sunday I went down to the plant and examined the boiler, but could not find any leak. The next morning the watchman reported that at 10 p.m., there was only 1 inch of water in sight, and at 3 o'clock it was down below the water-column connections.

The next Sunday I opened the back doors of the setting and could then hear water running from around the blowoff connections to the mud drum. I had examined that very place when the boiler had been under steam and there had been no evidence of a leak. Now the cause of the trouble was very evident. The blowoff was piped as shown in the accompanying sketch. The pipe from the mud drum to the valve was about 20 inches long. To the valve were connected an 8-inch nipple, an ell and a horizontal pipe, 20 feet long, which led to a conduit which contained all the drips. This pipe was completely imbedded in the cement floor, which came to within about 2 feet of the blowoff valve. The piping was immovable, and as there was no chance for expansion, either of the pipe or boiler, the drum had pushed and pulled on the pipe until the threads were practically stripped.



SHOWING HOW BLOWOFF WAS CONNECTED

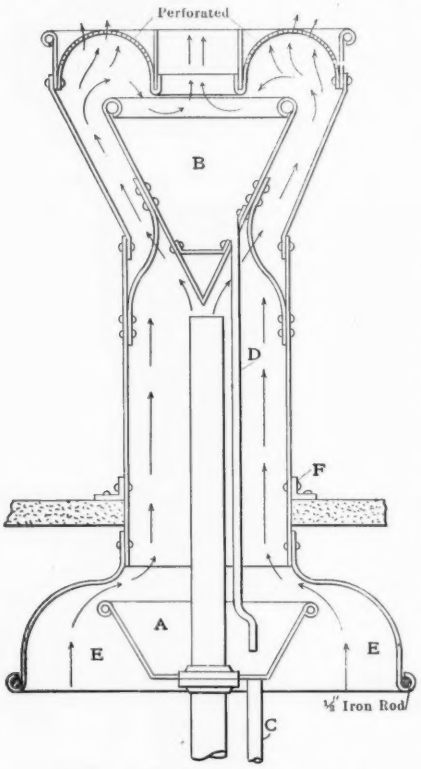
When hot, the expansion of the boiler forced the mud drum onto the pipe and the joint, being tapered, was perfect, but when cool the boiler contracted, pulling the drum partially off the pipe, causing the leak.

W. E. SARGENT.

Franklin, Mass.

Ventilator and Exhaust Head

In a certain cotton mill a large yarn room, owing to the absence of windows (the dyed yarn had to be kept more or less in the dark), was badly ventilated and in summer was uncomfortably warm. Near one corner was a 2-inch exhaust pipe from a small engine. This pipe passed through a hole in the roof and very little effort had been made to keep



VENTILATOR AND EXHAUST HEAD

out the rain, or tar from the roof. Finally an insurance inspector informed the management that more space must be allowed between the pipe and the roof boards. As the engineer was more or less in charge of building repairs, it was up to him to form plans to remedy matters.

The illustration shows a ventilator, wherein the exhaust was used as a blast to create a circulation of air in the room. The ventilator also forms an exhaust head and was made from heavy, galvanized iron.

The drip-pan *A* is held between the pair of flanges on the exhaust pipe and drained by the drip-pipe *C*. At *B* is another drip-pan drained by the pipe *D*. The lower hood *E* was placed and riveted after the ventilator was passed through the roof. The roof collar *F* was closely riveted and heavily soldered.

The roof around the ventilator was made tight in the following manner: First, the gravel was scraped off, leaving the tar paper clean, for a distance of 9 inches from the edge of the hole. Then a layer of tar paper was laid 3 inches from the edge of the gravel. This was cemented to the old tar paper with hot tar, care being taken that all edges were stuck and the paper lay smooth with no wrinkles. Another layer of tar paper was then laid in the same manner, but lapping over the other an inch, so that its edges lay within 2 inches of the gravel. The paper covering the hole in the roof was then cut out, the ventilator placed in position and secured with ¾-inch nails placed 2 inches apart. All nails entering cracks were taken out and the holes soldered up. The job was finished with hot tar and good clean and dry gravel.

R. O. Richards.

South Framingham, Mass.

A Piston Accident

In the October 6 issue, William J. Hackett wishes to know what caused his engine piston to break.

At one time I held the position of engineer on a private steam yacht equipped with a single, simple, vertical engine of 200 horsepower, operating at 150 pounds boiler pressure, and run noncondensing.

One day the owner started the engine without warning me of his purpose, and as a result the piston was broken in much the same manner as that shown in Mr. Hackett's sketch. The drips in this engine were open, but the condensation was too great for the cocks to relieve, and had they been four times as large the result would have been the same.

I do not say that this was the case with Mr. Hackett's engine, but it looks very much that way. Nothing but water or some other incompressible substance caused the break, and the fact that his drip cocks were open means little without some additional information. By incompressible substance I mean a piece of metal, such as a follower nut or a fragment from a broken valve.

L. F. Wilson.

Chicago, Ill.

Lessons from Boiler Explosions

The disaster at the Susquehanna Steel Company's plant, York, Penn., and the publicity given it and its causes, attracted considerable attention among those interested in the operation of plants embracing similar installations. As an instance of the value of such publicity and associated opinions expressed editorially is the case of an Illinois plant which has been equipped with auxiliary boilers such as that which caused the disaster mentioned. A visitor who was being shown through the forge shop noted that the customary old locomotive boilers were not in their wonted positions over the forge fires. Upon asking the reason for their absence, the superintendent stated that he had read "an article" recently which had set him to wondering if his own installations were safe, and an examination followed which resulted in their removal.

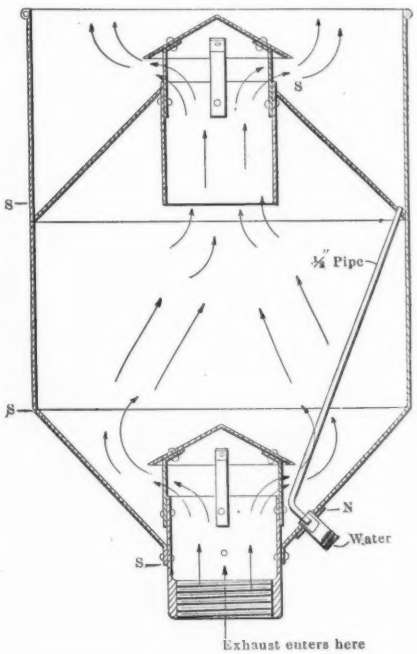
The narration of such cases as these are only of value in that they illustrate the point in question suggested at the beginning of this letter. Nobody is qualified to state that had these boilers been left at work they would have exploded with fatal results. It can be stated, however, that but for the article in question, they would still be in position, performing work for which they had been long unfitted, and as a result they might have destroyed life and property. The fact that they were removed in all haste upon examination proves this last statement.

L. F. Wilson.

Chicago, Ill.

Efficient Exhaust Head

The accompanying drawing shows a cross-sectional view of an exhaust head which the writer made and used a few years ago. The head is built up from the 4-inch pipe coupling to which the No. 20 galvanized-iron shell was secured. The strips holding the conical caps over the inlet and outlet were made of ⅛x¾-inch iron. The coupling is shown bored out at one end, to give the rivet heads a smooth surface to seat against.



SECTIONAL VIEW OF EXHAUST HEAD

Little explanation is necessary. At *N* is a lock nut soldered on for attaching the drain pipe; *S S S S* represent joints, which should be soldered. The ½-inch pipe conducting water from the top to the drain is also soldered. The arrows show the flow of steam. The diameter of the shell should be four times that of the exhaust pipe, and the outlet one and one-half times. The drain from the base should be one-fourth that of the exhaust pipe, and the pipe from the top to the

drain, one-half the diameter of the drain. The joint attaching the head to the coupling should be riveted as well as soldered. On sizes above 4 inches I should suggest that all joints be riveted.

GEORGE R. WILLIAMS.

Findlay, Ohio.

The Action of Expanding Steam

In W. H. Wakeman's "simple and plain illustration and explanation," on page 702 of the October 27 number, he entirely fails to prove that the pressure to which the steam in the reservoir falls is 78 pounds gage, as stated in his article on page 137 of the July 28 number; and, in fact, no illustration, explanation, or anything else can ever make steam act first as a non-expanding body for a short period and then spontaneously recover its usual properties, as it would have to in order to fulfil his calculations, as shown in the article in question.

As to my claiming that the formula

$$\frac{\text{Initial Absolute Pressure}}{\text{Ratio of Expansion}} = \text{Final Pressure}$$

is more correct than

$$\frac{\text{Initial Volume} \times [\text{Initial Pressure}]}{\text{Final Volume}} = \text{Final Pressure},$$

it is utterly absurd, for they are both practically the same thing, being based on Marrott's law. I stated that steam probably never expands according to Marrott's law.

I do not think Mr. Wakeman has grasped the point I brought out in my letter on page 448 of the September 15 number, or he would know that what he claims could *never* take place under such stated conditions.

GEORGE P. PEARCE.

Exeter, N. H.

Given the pressure in the reservoir at admission, Mr. Wakeman wishes to find the pressure at cutoff. Applying Boyle's or Marrott's law ($p_1 v_1 = p_2 v_2$) for a perfect gas at constant temperature to the expansion of steam, he reaches the result that the final pressure in the reservoir is 78 pounds gage, but in applying this formula he makes the mistake of using for the final volume the initial volume, and for the initial volume the volume of the reservoir, less the volume of the steam in the engine cylinder.

On page 448 of the September 15 issue, Mr. Pearce takes up this point in Mr. Wakeman's article, and correcting his mistake in the substitution of the volumes, obtains from the perfect gas formula a pressure of 82 pounds gage in the reservoir at cutoff.

Actually steam does not follow the law for perfect gases, and a different method must be used to solve this problem correctly. At a pressure of 115 pounds absolute, steam has a volume of 3.864 cubic feet per pound. The ratio of expansion is

$$\frac{11{,}457}{9{,}648} = 1.187;$$

therefore, the volume of a pound of steam at the final pressure would be

$$1.187 \times 3.864 = 4.586$$

cubic feet. This corresponds to a pressure of 81 pounds gage.

While the pressure obtained by using the steam tables and by applying the law for perfect gas differ but slightly in the example cited, due to the small expansion ratio, it is certain that the law for a perfect gas cannot be applied to the expansion of steam; and in most cases, when the expansion ratio is that which occurs in practice, the error would be considerable.

On page 702 of the October 27 issue, Mr. Wakeman replies to Mr. Pearce's criticism of his article and, failing to see the correction made, attempts to show that he is right by assuming an example requiring the gage pressure at the end of the stroke of an engine; the volume of the cylinder, initial pressure and cutoff being given. He uses the formula given by Mr. Pearce, and states that he is unable to understand how Mr. Pearce can be all right and he all wrong when both formulas give the same result.

If the value for the ratio of expansion,

$$\frac{\text{Initial Volume}}{\text{Final Volume}},$$

be substituted in Mr. Pearce's formula, the two become identical, and would naturally give the same result if used correctly, which Mr. Wakeman does in the example given. The actual pressure in the engine at the end of the stroke would be somewhat lower than that given, since Mr. Wakeman again falls into error by applying the formula for a perfect gas at a constant temperature to the expansion of steam. It might also be well to call attention to the fact that in any problem of this kind the clearance volume must be added to both the initial and final volumes to obtain the correct result, or that the expansion ratio is equal to

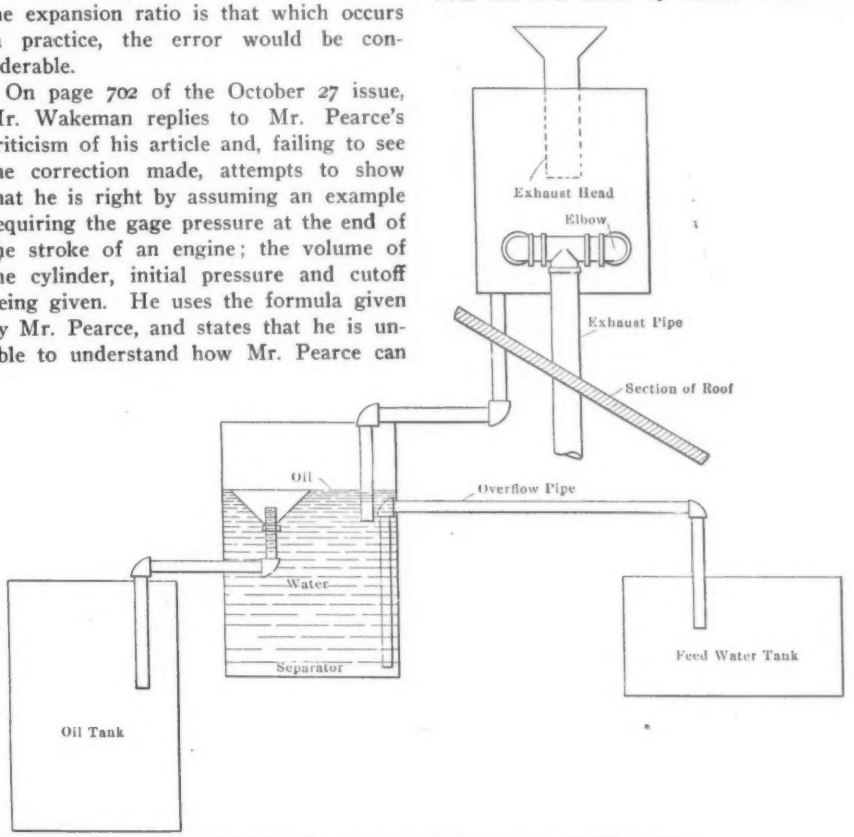
$$\frac{1 + \text{Clearance}}{\text{Cutoff} + \text{Clearance}}.$$

W. L. DURAND.

Brooklyn, N. Y.

The Recovery of Cylinder Oil

Following is a good, cheap plan for the recovery of cylinder oil: The exhaust head shown in the illustration was made from an old ammonia drum. The fittings were all 2-inch. The drum from the exhaust head runs into another ammonia drum, with the end about 15 inches below the top. This drum has an overflow, 12 inches below the top of the 2-inch pipe, discharging into the feed-water tank. The oil from the separator is discharged into a funnel after a few inches of it has risen to the top of the water, and is delivered to the oil tank.



ARRANGEMENT FOR THE RECOVERY OF CYLINDER OIL

J. AUSTIN PHELAN.

St. Louis, Mo.

Natural Gas Furnace Data Wanted

Can any reader give data for constructing a natural-gas furnace for melting brass in crucibles of about two gallons capacity?

R. ANDREWS.

Parsons, W. Va.

An Appreciative Reader

I let nothing come between myself and POWER, as it would isolate me from the engineering fraternity and narrow me down to my own plant. It is the medium through which the thoughts and researches of others become my property. I read the descriptions of new plants and obtain ideas for improving mine. The technical articles become part of my education, stored for future use. The practical letters at times give valuable experiences and suggestions, although some are so ridiculous as to be amusing, while others of a doubtful nature serve their purpose by giving topics for investigation, or start an interesting argument. Through the advertising columns I receive a weekly visit from the manufacturers of things I use, or may want to use. I obtain valuable information on all the latest appliances and the names of firms manufacturing them. I scan the list of catalogs published and select those I wish to have on file, always acknowledging those received.

The editors of POWER are my consulting engineers, and many times during the year give me expert advice, which I could not otherwise obtain.

My copy of POWER is a badge of my profession. The letter carrier sees it with my name on the wrapper, my visitors see it on my desk, and the row of bound volumes in my bookcase. It is one of my assets.

Engineering pays, and there is lots of room for advancement. If a man is really an engineer, if he is interested in his work, if he is taking the many opportunities to investigate and obtain knowledge, and is keeping up to the times, it pays; if it doesn't, it is generally his fault.

L. C. REYNOLDS.

Willard, N. Y.

Requires a Drip

On page 540 of the September 29 issue, Fig. 1 in my letter is misleading in that that it says: "No drips required." There should be a drip that can be opened when the engine is shut down, and be closed when running. It is correct that no drips are required when running.

There is another way a horizontal heater could be made, that would require no drips. Get a pattern of a head made that had the opening for the exhaust on one side, and put the exhaust connection at the top on the end leading from the engine, and at the bottom on the condenser side or end of the heater. This would always be drained where the condenser was lower than the exhaust. Where the pipe runs vertical beyond the heater, it would be necessary to have a drip at the ell to open nights.

W. E. CRANE.

Broadalbin, N. Y.

A Homemade Grinder Stand

Fig. 1 shows an inexpensive tool-grinder stand, made from scrap pipe and a few fittings. As will be seen, the outfit consists of three tees, two ells, four nipples, one flange and a straight piece of pipe of convenient length and size. The shaft is centered in the tee bearings and

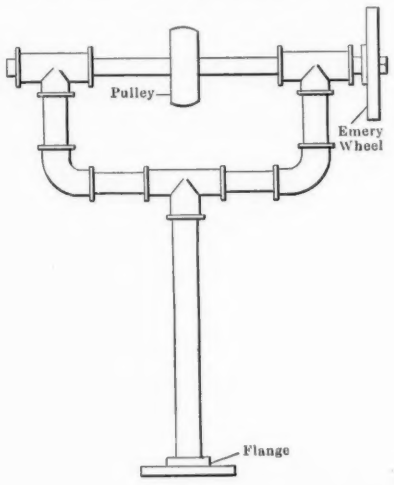


FIG. 1

babbitt metal is poured around it, forming the bearing, after which the shaft is removed and the bearing reamed slightly to allow the shaft to revolve easily. The emery wheel is placed on the shaft in the usual manner, and cotter pins or nuts may be put on the shaft to prevent end play. If it is desired to have the stand heavier than the bearing parts, reducers may be used to effect the change from larger to smaller pipes.

This device may be converted from one of utility to one of pleasure and com-

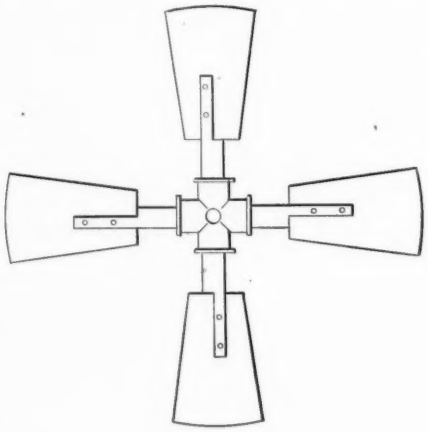


FIG. 2

fort by using the fan shown in Fig. 2. This fan is made from a cross, four pieces of pipe and four blades of sheet iron. A hole is drilled through the center of the cross to receive the shaft and a slit sawed in each arm to receive the sheet-iron blades, which are riveted in place as shown.

C. L. GREER.

Handley, Tex.

Flickering Lights

In regard to Mr. Carroll's trouble with flickering lights, as mentioned in the issue of October 20, I would say that if the 25-kilowatt machine is compound wound, with a shunt across the series field, the trouble may be due to the choking effect of the field, due to the inductive resistance set up by the increasing current in it. In such a case a large part of the current will pass over the shunt and for an instant the same effect would be had as with a shunt-wound generator; that is, a drop of voltage when the load comes on, due to the lack of additional field strength to overcome the extra armature reactance.

It will be noted that after the motor has been started and running and the current has adapted itself to the value required to carry its load, the voltage then returns to normal, or a little above. This shows that the current in the series field has attained its value and supplied the additional field magnetism to overcome the armature reactance. I have noticed that on removing the shunt, the flickering of the lights does not stop, but is caused by a different effect, i.e., the voltage rises instead of decreases.

By placing a shunt of sufficient ohmic and inductive resistance across the series field so that it will have the same time-constant as the field, the trouble may be minimized if not eliminated. This probable remedy is based on the assumption that the driving speed remains constant and that there is sufficient copper in the leads from the generator to the busbars.

If the elevator motor is controlled by a magnetic controller, sometimes the dash-pot does not give the required damping effect, and the resistance is cut out too quickly. This causes the motor to take excessive current at the start. In other types of magnetic controller, in which each resistance notch is controlled by a separate magnet, the same action takes place, as it is not uncommon to see all the resistance and reversing fingers pulled closed before the motor has time to start. Probably the trouble could be remedied by adjusting the controller.

The trouble Mr. Carroll mentioned is experienced in the majority of plants in small office buildings where the elevators are electrically driven, and in some places the same remedies as Mr. Carroll suggests have been adopted, i.e., keeping the lighting load and the elevator load separated.

JAMES E. KILROY.

Lincoln Place, Penn.

The letter by Mr. Carroll suggests a somewhat similar experience I had in the plant where I am employed. We have a 62½-kilowatt 250-volt direct-connected generator, and two electric elevators, each

having a starting load of 100 amperes, dropping to nothing on the up trip and about 20 amperes on the down trip. One car runs continuously all day, and part of the day both cars are running. This plant is in an office building and when the elevator started the voltage would drop from 10 to 20 volts. The tenants would not stand for this and something had to be done.

We installed a storage battery consisting of 120 cells in the main battery and 20 end cells. Now, when both elevators start at the same time, one can hardly notice a drop in the voltage. The battery is floated on the line all day and all the elevator load falls on the battery instead of on the machine. A booster set is used for charging.

The battery is large enough so that we can charge at a somewhat higher rate than our discharging rate, thereby having the battery fully charged by night. The plant can be shut down part of the night and what current is used during that time is supplied by the battery. The battery is in a room by itself, well ventilated, and all iron work is given a good coat of asphaltum paint, so that there is no trouble from fumes. The battery has been in operation five years and has given no trouble whatever.

I think a storage battery is the only way of solving Mr. Carroll's problem. His 25-kilowatt machine would then take care of the day load with ease.

NORMAN S. CAMPBELL.

Detroit, Mich.

Design of a 25-Horsepower Gas Producer

I beg to submit the following comments on Mr. Tryon's article on the "Design of a 25-Horsepower Gas Producer," which appeared on page 641 of the October 20 number.

First, in reference to the grate construction: It is poor policy to require the top of the producer to be removed to replace a grate section. It quite often happens that a grate bar is broken by barring, and a method of quickly replacing the broken member, even while the producer contains a fire, is necessary.

More details should have been shown of the three-way valve between the producer and scrubber, as this is a very essential part of the installation. It has been quite difficult for manufacturers to provide an effective and practical valve at this point, much trouble being caused by leakage. The material is also an important consideration.

Although many producers are constructed with the air pipe entering the producer directly under the grate and stopping there, this is poor practice. It is readily seen that the air and steam entering just inside the producer will creep up the lining and cause a hole in the fire on that side, causing an excess of CO_2 in the gas and permitting the formation of clinkers on the opposite side. This trouble would be aggravated by taking the gas off on the same side as that on which the air and steam enter, as shown by Mr. Tryon's drawing, and this is an undesirable feature, even when the gas is taken off on the opposite side, thus permitting it to take a diagonal path across the fire bed.

The better way would be to carry the air pipe to the center of the producer under the grate and there distribute the steam and air by means of a cross or special fitting, with pipes extending radially nearly to the edge of the grate and with elbows on the ends turned down to prevent clogging with ashes. While this would be a little more expensive and not quite so simple, the advantage gained in operation would be worth while.

Water should not be distributed in the scrubber through a pipe capped and drilled full of holes. It would be a matter of a very short time for these holes to clog (especially if there is only a 1/16-inch drain), as the writer has found in experimenting with a similarly constructed apparatus. Some form of spray as made by manufacturers would be less likely to clog, more accessible and no more expensive.

Mr. Tryon's statement in regard to economy is somewhat misleading. He says that "with a 3-foot depth of bed there will be fuel enough to run a 25-horsepower engine full load for about 18 hours." The area of a 2-foot fire column is 3.14 square feet. Then the volume of coal with a bed 3 feet deep equals

$$3.14 \times 3 = 9.42$$

cubic feet. According to Kent, page 625, a cubic foot of pea coal weighs 61 pounds and

$$61 \times 9.42 = 575$$

pounds = the weight of coal in the producer when 3 feet deep. Now 25 horsepower for 18 hours is

$$25 \times 18 = 450$$

horsepower-hours, and at 1¼ pounds of coal per horsepower-hour the actual amount required, not counting any waste or stand-over loss, is

$$450 \times 1\tfrac{1}{4} = 562$$

pounds, leaving 13 pounds of coal and probably 65 pounds of ashes on the grate at the end of the 18-hour run.

The statement, therefore, is not exactly correct, for, while it requires only 562 pounds to run 18 hours at 25 horsepower, still this could not be done at one filling of the producer; in fact, after 3 or 4 hours the gas would be found to be so poor that it would be desirable to put in more fuel.

It would have to be a very good coal indeed to require barring down only once a day for the type of producer shown in the sketch. After testing many samples of coals in a producer of similar, but better, design, the writer has not yet found one that could be run all day at full load with only one barring down. Many required barring as often as every half hour, and if left longer would require driving the bar through the clinker with a sledge.

Cleaning the fire on top of the grate will be necessary at intervals of from 2 to 6 hours, depending chiefly on the coal. Before this is done each time, water should be run into the ashpit, so that any hot coals or ashes raked off of the grate will cause formation of steam, which is taken through the fire bed and minimizes the tendency of the engine to drop its load, which is very liable to happen in this style and size of plant.

H. G. D. NUTTING.

Madison, Wis.

Wants Information About Twisted Wire Cable

I would like to have some reader explain how wire of about No. 8 gage is twisted into braces of certain length and under certain tension, such as are used in windmill construction for braces.

F. FROST.

Evansville, Wis.

Troublesome Storage Batteries

We have a number of 7 S. N. exide storage batteries that have troubled us by becoming dead a short time after charging. They have been treated as follows: The plates were assembled with the necessary wood-and-rubber separators. The acid, of 1210 degrees temperature, was put in the jar and allowed to stand for 12 hours and then given an initial charge of 50 hours. They were then worked for 30 days, after which the acid was diluted with distilled water and the batteries re-charged. These cells have been in operation for one year on automatic signals, and have been re-charged every 30 days.

The cells come with the wood separators in very bad condition, and the negative plates badly swelled. When the new separators are put in place they are so large that it is necessary to scrape the active material off when placing the group in the hard-rubber jar. The temperature where these batteries work goes up as high as 122 degrees Fahrenheit, and seldom below 60 degrees Fahrenheit. They are set in the bottom of the signal case, and when the door is opened the air is so warm that it feels as though it came from a furnace.

I would like to know if any readers can tell me the cause of the trouble and suggest the proper treatment of the batteries.

J. M. HERWIG.

Benson, Ariz.

The Ultimate Analysis of Coal

In Which the Hydrogen, Total Carbon, Oxygen and Nitrogen Contents Are Expressed in Curves Based on the Government Analyses of Coal

BY LIONEL S. MARKS

In all heat-engine and boiler investigations in which coal is used, some sort of analysis of the coal is necessary. For most purposes the proximate analysis, that is, the determination of the percentage by weight of its content of moisture, volatile combustible matter, fixed carbon and ash, suffice. There are some cases, however, in which further analysis is necessary, particularly for the determination of the amount of hydrogen in the coal. In boiler tests, for example, if the heat losses up the chimney are to be determined in detail (as recommended in Section XXII of the code of the American Society of Mechanical Engineers for steam-boiler trials), the percentage of hydrogen in the coal must be known. In producer tests, if the efficiency of the producer is to be based upon the lower or effective heating value of the coal, the hydrogen content must be known. To determine the hydrogen content, the only practicable method has been to make the so-called ultimate analysis of the coal by slow combustion and the absorption and weighing of the water formed. This analysis requires special skill for accurate results and is better carried out by a chemist who is accustomed to such manipulations than by an engineer to whose general work they are distinctly foreign. The trouble of making the ultimate analysis has prevented the general use of this analysis and has recently been advanced as a reason for using an inconsistent method of defining the efficiency of a gas producer.

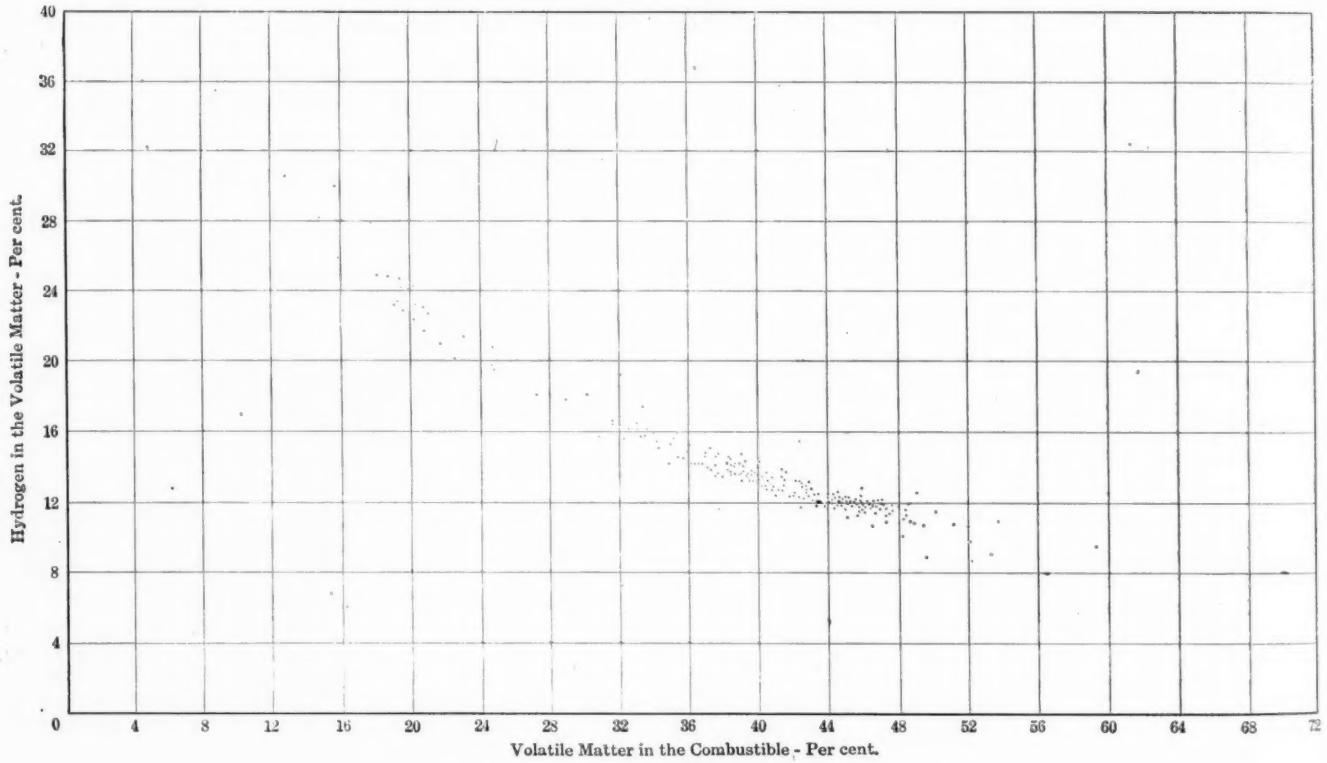


FIG. I. HYDROGEN CONTENT OF THE VOLATILE MATTER

The ultimate analysis of coal includes not only the determination of the hydrogen present, but also of the total carbon, oxygen and nitrogen. These determinations may all be of use in special cases, but it is the hydrogen which is most frequently desired. The writer finds that there is a very simple relation between the hydrogen content of a fuel and the amount of volatile combustible matter in the fuel. When the proximate analysis is known, this relation permits the determination of the hydrogen content of a fuel with an accuracy which is sufficient for all heat-engine investigation purposes.

The U. S. Government has been engaged during the last four years in carrying out tests of the fuels occurring in the United States. These tests include proximate and ultimate analyses of each coal investigated. The analyses have all been made under such conditions as to permit full confidence in them. Those that have been published so far are given in three annual bulletins; they include the analyses of about 240 different coals from 28 States and Territories, and represent every kind of fuel from anthracite to peat and a range of volatile matter in the combustible of from 8 to 70 per cent. This series of analyses gives a splendid foundation on which to base any general conclusions as to the composition of fuels. For each coal several samples were analyzed, including one collected at the mine, one taken from the car bringing the coal to the testing plant, one collected during the boiler test, etc. In the results that follow the analyses of the car samples were used in every case. The analyses are published in the form shown in the following example:

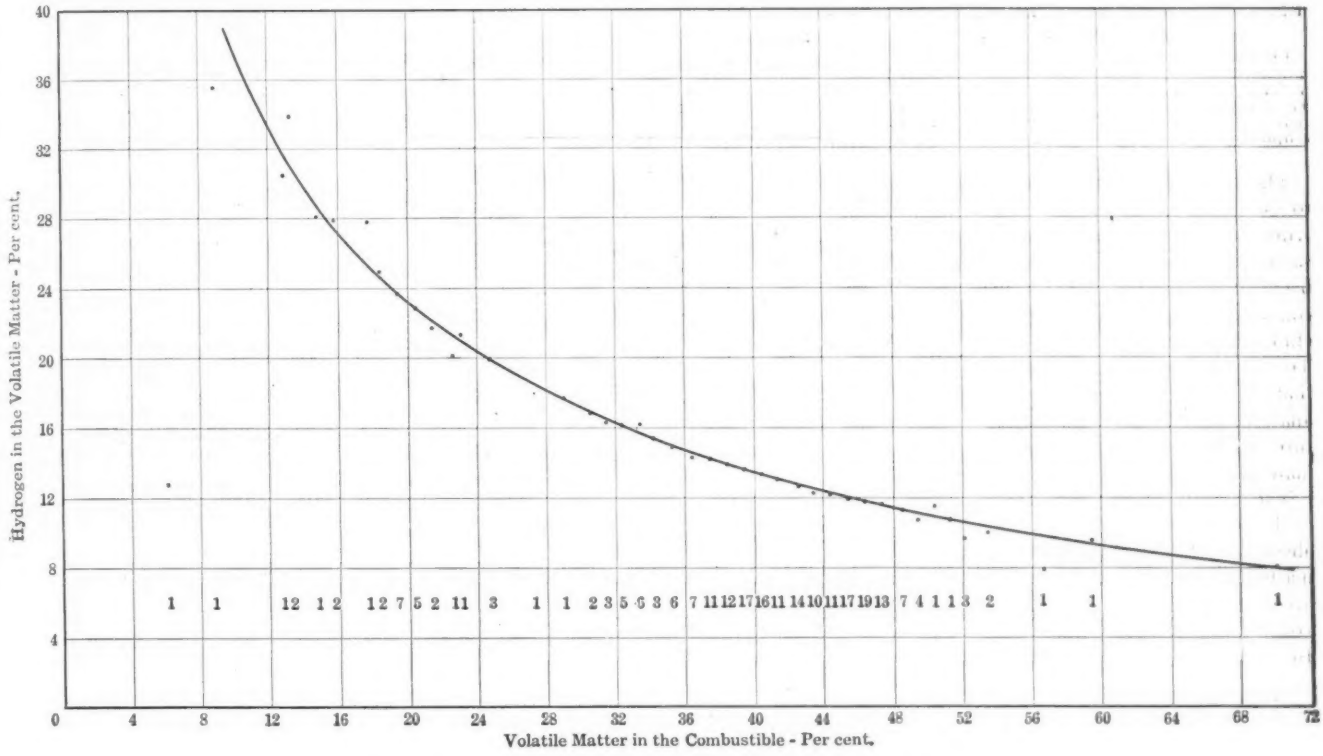

Hydrogen in the Volatile Matter - Per cent.
Volatile Matter in the Combustible - Per cent.
1 1 12 1 2 12 7 5 2 11 3 1 1 2 3 5 6 3 6 7 11 12 17 16 11 14 10 11 17 19 13 7 4 1 1 3 2 1 1 1

FIG. 2. AVERAGING HYDROGEN CONTENT OF THE VOLATILE MATTER

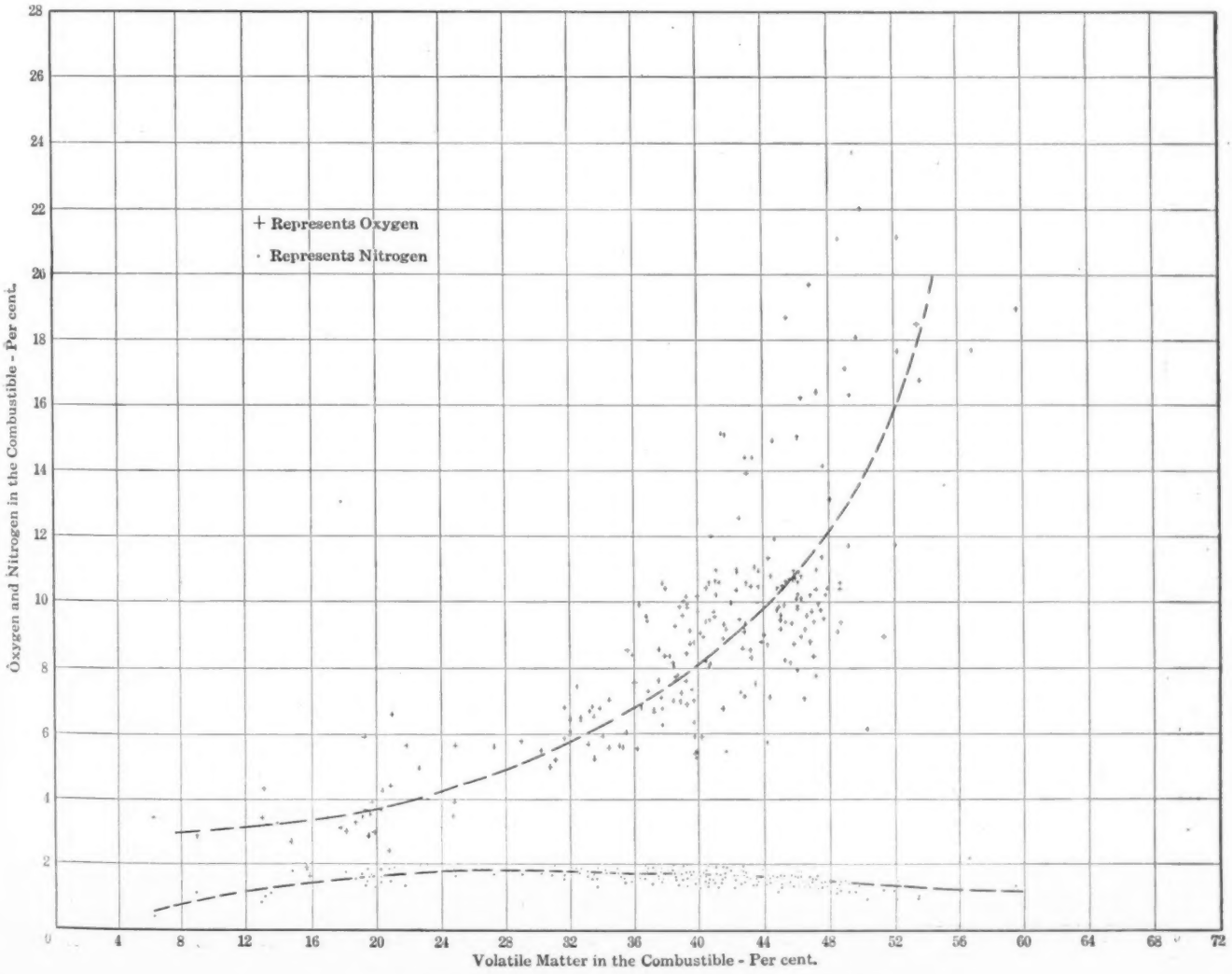

+ Represents Oxygen
· Represents Nitrogen
Oxygen and Nitrogen in the Combustible - Per cent.
Volatile Matter in the Combustible - Per cent.

FIG. 5. OXYGEN AND NITROGEN CONTENT OF THE COMBUSTIBLE

KENTUCKY COAL NO. 6, BULLETIN NO. 290, PAGE 126.

Proximate Analysis.		Ultimate Analysis.	
Moisture	5.12	Ash	2.76
Volatile matter	36.49	Sulphur	0.57
Fixed carbon	55.63	Hydrogen	5.47
Ash	2.76	Carbon	77.20
Sulphur	0.57	Nitrogen	1.45
		Oxygen	12.55

The moisture and the ash in a coal are to some extent accidental and will vary from sample to sample taken from the same seam of coal. The analyses have all been recalculated so as to express the composition in terms of dry combustible, eliminating the moisture and ash entirely. To make this recalculation it was assumed that the sample used for the ultimate analysis had the same percentage of moisture as the sample used for the proximate analysis.

The results of the analyses of all the coals tested are given in Fig. 1. The abscissas are the percentages of volatile matter in the combustible; the ordinates are the percentages of hydrogen in the volatile matter (not in the combustible). In the region from 36 to 48 per cent. of volatile matter the points lie so close to one another that it is not possible to show them all in a figure of moderate dimensions. It will be seen at once that the plotted points fall very close to a smooth curve. To draw the curve accurately the average position of the points was calculated for each 1 per cent. range of volatile matter, and these average points are given in Fig. 2. Each point between 36 and 48 per cent. volatile matter is the average of from 10 to 19 analyses; over 50 per cent., most of the points represent one analysis only; from 18 to 32 per cent., the only points not very close to the curve represent one

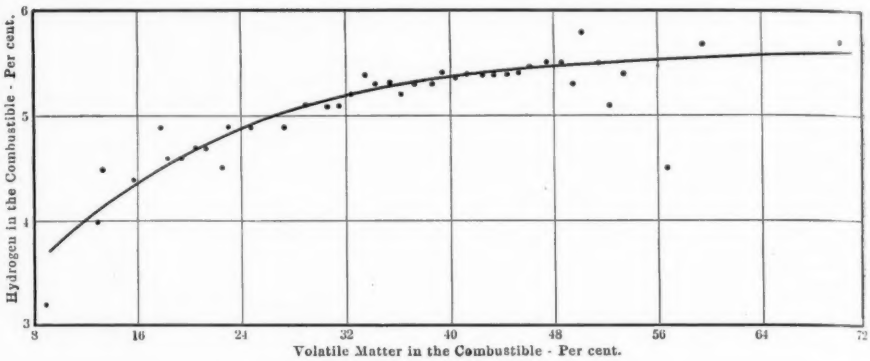


FIG. 3. HYDROGEN CONTENT OF THE COMBUSTIBLE

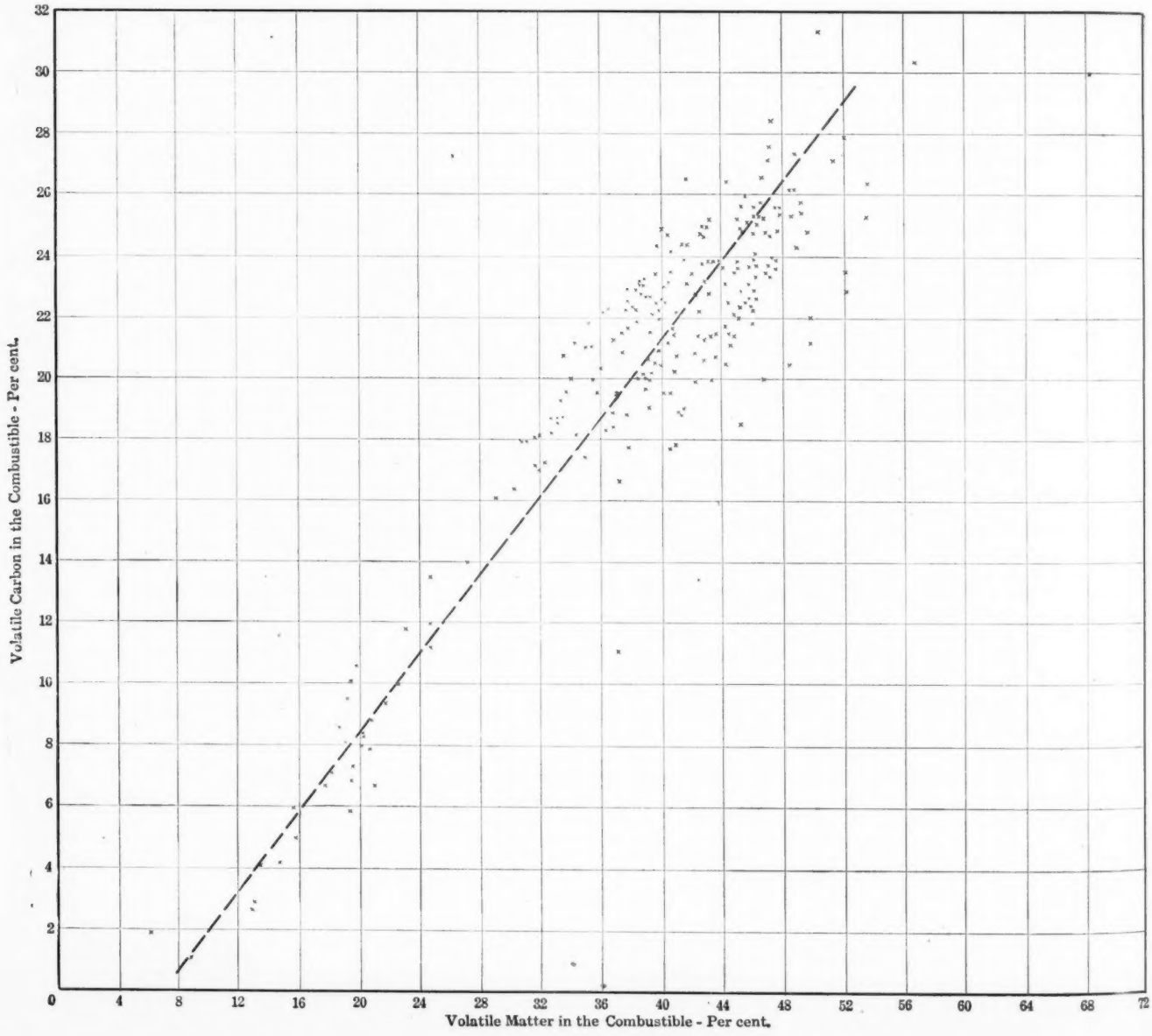


FIG 4. VOLATILE CARBON CONTENT OF THE COMBUSTIBLE

analysis only; below 18 per cent., each point with one exception represents one analysis only. The number of analyses of which each point is the average is given on the diagram.

The percentage of hydrogen in the combustible has also been calculated and the results averaged for each range of 1 per cent. in volatile matter. The average points are plotted in Fig. 3.

Over 90 per cent. of the fuels tested have an amount of volatile matter which is between the limits of 18 and 48 per cent. of the combustible. Within this range the points are seen to lie remarkably close to the curve. The use of the curves for the determination of the hydrogen in the volatile matter would have given less than 2 per cent. maximum error within that range, or about 0.5 per cent. in the determination of the amount of hydrogen in the combustible. As the points represent tests of over 200 different coals, the curve can be used with confidence for all semi-bituminous or bituminous coals occurring in the United States.

Above the limit of 48 per cent. of volatile matter in the combustible lie some of the lignites and the peats. There is rather more average variation here, though the maximum error again by the use of the curve would not be more than 2 per cent. in terms of the volatile matter, or a possibility of about 1 per cent. error in the determination of the percentage of hydrogen in the combustible.

Below 18 per cent. volatile matter are the semi-anthracites and anthracites. These show somewhat more variation than in the middle range, but the possibility of error in determining the hydrogen in the combustible from the curve is only one-quarter to one-half of 1 per cent. Of all the coals tested there is only one which has a hydrogen content differing considerably from that given by the curve, and that was a coal with only about 6 per cent. of volatile matter and which is described as an anthracite-graphite coal mined in Rhode Island. If the curves of Figs. 2 or 3 had been used for determining the hydrogen content of the dry coal, the results obtained would have differed from the analyses less than two-tenths of 1 per cent. In 90 per cent. of the coals, and for one coal only, would the difference have been greater than 1 per cent. One per cent. error in the determination of the hydrogen will cause an error of about 100 B.t.u. in the determination of the latent heat of the steam formed by the combustion of one pound of combustible, or about seven-tenths of 1 per cent. error in the calculation of the lower or effective heat value of the coal. This is the limit of error by the use of these curves. The probability of error for fuels which are neither extremely high nor extremely low in combustible matter is not more than one-tenth of 1 per cent.

The accompanying table is taken from the curves in Figs. 2 and 3:

Per Cent. of Volatile matter in the combustible.	Per Cent. of Hydrogen in the Volatile Matter.	Per Cent. of Hydrogen in the combustible.
10	37.6	3.8
12	33.4	4.0
14	29.9	4.2
16	27.2	4.35
18	25.0	4.50
20	23.2	4.65
22	21.7	4.78
24	20.4	4.9
26	19.2	4.98
28	18.1	5.03
30	17.1	5.13
32	16.2	5.17
34	15.4	5.22
36	14.7	5.27
38	14.0	5.32
40	13.4	5.36
42	12.9	5.38
44	12.3	5.40
46	11.8	5.42
48	11.3	5.44
50	10.9	5.45
52	10.5	5.46
54	10.2	5.47
56	9.8	5.48
58	9.5	5.50
60	9.2	5.52
62	8.9	5.53
64	8.6	5.54
66	8.4	5.56
68	8.2	5.58
70	8.0	5.60

Besides the hydrogen content of the fuel the total carbon is sometimes required, particularly for such purposes as the calculation, from the composition of the gas, of the total volume of gas resulting from the combustion of a fuel in a boiler or producer. There appears to be no simple relation between the amount of volatile matter and its carbon content. The carbon in the volatile matter of the coals where analyses are given in the U. S. Government bulletins is plotted in Fig. 4. If the relation between the volatile carbon and the total volatile matter were assumed to be that represented by the dotted line, it would lead to errors in the determination of the total carbon which in several cases would be as great as 5 per cent.

The oxygen and nitrogen contents of the combustible are shown in Fig. 5. It is obvious upon inspection that there is no constant relation between the oxygen and the volatile matter. The nitrogen is very constant in amount; it is between the limits of 1 and 2 per cent. for over 95 per cent. of the coals tested.

To determine the total carbon in the fuel, the simplest method is to absorb and weigh the carbon dioxide contained in the bomb calorimeter after the calorific value of the fuel has been determined. This method will not do for the determination of the hydrogen in the coal, because the sulphur of the coal is converted in the calorimeter into sulphuric acid, which combines with any moisture present.

On page 787 of the November 10 number we published, under the caption "Possibilities of Low Pressure Turbines," an abridged report made to the management of the Cambridge (Mass.) Electric Light Company, crediting the report to Lionel S. Marks, assistant professor of mechanical engineering at Harvard University. The report was not made by Mr. Marks, but by Prof. Ira N. Hollis

Oldest Engineering Organization Entertains

On Wednesday evening, November 11, the New York Engineers' Protective Society held its fortieth annual entertainment and reception at Lyric hall, Forty-second street and Sixth avenue, New York City. The entertainment, which was provided and directed by Daniel W. Quinn, consisted of a round dozen musical and vaudeville selections and was enjoyed by a large and appreciative gathering of members, with their wives, daughters, sweethearts and other guests. After the entertainment dancing was indulged in. Among the guests were members of other engineers' organizations and friends from various supply houses.

This society is probably the oldest organized body of stationary engineers in the country, having had a continuous existence since its formation in March, 1867. After an independent existence of about 20 years the society became one of the subordinate associations of the National Association of Stationary Engineers. Five years later it withdrew from the national body and again took up its independent existence, which it has continued ever since.

Its objects are both fraternal and charitable. Funds are maintained for the purpose of helping sick and unemployed members, widows and orphans and for the burial of the dead, more than $30,000 having been paid to widows and orphans alone since the beginning.

The membership has grown steadily, the losses by death and withdrawal being more than made up by the admission of new members, many of them being from the younger class of engineers, to whom the benevolent and insurance features appeal, as well as the educational advantages offered by the winter course of lectures and discussions.

Westboro N. A. S. E. Reunion

Westboro (Mass.) Association No. 21, N. A. S. E., held its annual reunion and banquet Saturday evening, November 21. The hall was filled with members and guests from sister associations, national and State officers and newspaper men. The gastronomical feast was followed by a flow of oratory from several talented speakers, under the direction of Toastmaster Turner.

The meeting, which broke up in time to allow visiting members of the order to catch the Sunday morning newspaper train, was pronounced by all who attended it "the best ever."

The American Society of Agricultural Engineers will meet at the University of Illinois, at Urbana, Ill., on December 29 and 30.

POWER AND THE ENGINEER

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Leather Belting versus Rope Drives

In his paper upon "Leather Belting Compared with Rope Drives," presented at the recent meeting of the Leather Belting Manufacturers' Association, Harrington Emerson evidently holds a brief for the leather belt. There is undoubtedly a field in which this method of transmission is superior to the rope drive, but it is equally true that there are conditions under which the rope drive is the better. These fields overlap upon a debatable territory where the superiority of either method is not so manifest. A full and free discussion of the subject, bringing out real information in the way of costs of installation and maintenance, of durability and efficiency, would be of service in narrowing the bounds of this debatable territory and enabling the designer or prospective purchaser to determine more readily what was best for his especial case, and we shall be glad to have our columns made the forum for such a discussion.

Station Water Rate

Next in importance to the coal consumption of a generating plant per kilowatt of output is the water rate, which, in conjunction with the coal consumption, is the measure of the efficient operation of the boilers and furnaces. In most plants the only method of measuring the water used is the meter at the city water service, whose readings record the entire consumption of the building for boilers, house service, elevators, etc. Some few plants have installed additional meters in the pipe lines to the feed tanks, and in one or two cases in the feed lines to the boilers; but the trouble in calibrating and the uncertainty in the meter readings soon lead to the disuse of the meters.

At present we do not know of one plant in which the water rate is known with a reasonable approach to accuracy, and this in a time when leaks and wastes are receiving more attention than ever before in the history of engineering. That there are wastes to be discovered cannot be doubted by any one familiar with plant design and operation, and in the larger field of city water-pumping practice much water and power have been saved by the installation of accurate meters, and the slip of the valves in the large pumping engines has been kept within the allowable three per cent. limit.

The meter used in this case, the Venturi, seems particularly adapted to the varying pressures and temperatures in feed-water service and several installations of these meters in the feed lines between the pumps and boilers are now being made. If the drips are returned to the boilers direct, the blowoff led into a tank and a record kept of the number of times the tank is filled, a comparatively good foundation for the station rate may be obtained.

Value of Organization

Only a few years ago the duties of the stationary engineer consisted solely in the operation and management of steam engines and boilers, and the position he held was usually anything but a desirable one.

If he desired information on any subject connected with the operation of the machinery under his care, he could consult some of the few unreliable textbooks on the subject, written by men of limited training and experience. He could seek help from some other engineer, whose experience was probably as limited as his own, a course which oftener brought humiliation than relief, or he could work out for himself some sort of a solution as frequently wrong as right. But in most instances he remained in ignorance in preference to exposing his lack of knowledge and running the risk of ridicule from fellow craftsmen, who were under no obligation to aid him.

Organization had not been considered and engineers' associations were unknown. Some far-sighted members of the craft saw the benefits of organization and cooperation in other lines, and realized that if the unorganized units were gathered into a coöperative body of national character, inestimable benefit would come to the membership. As a small organized army is more efficient than a large, unorganized mob, so it proved with the engineers' associations. In some associations education is the keynote; in others it is a banding together for mutual protection and advancement, while in still others the fraternal and benevolent features are most pronounced.

To which type the engineer should attach himself must be decided by him according to the circumstances, but of some one he should be an active member. In these days of rapid advancement no man, and least of all an engineer, can afford to remain "sufficient unto himself." Men whose interests are identical derive advantages from association and the interchange of ideas and experiences that cannot well be ignored, and however limited a man's leisure hours may be, the regular meetings of his trade organization should not be neglected.

An engineer is expected to take a lively interest in all matters pertaining to the art and science of steam engineering, and nowhere will he get so great a return for the effort expended as in gatherings of engineers.

One thing is certain: To reach and to stay in the front rank, the engineer must study. To be sure, a man of studious habits may learn much alone, but the

knowledge so gained will not have the value to him or his employer which will belong to that which he has acquired by constant contact with other engineers.

Chemistry in the Boiler Room

When the term "chemistry" is mentioned to the average engineer or fireman, his mind conjures up a meaningless jumble of testing tools, retorts, stained fingers, burnt clothing and disagreeable fumes. To be sure, the chemist deals with all these, and more; but in reality they have little to do with the boiler room, where it is only necessary for the attendant to apply the knowledge worked out for him by those expert in the art.

Many steam-plant employees, if asked regarding their knowledge of chemistry, would demand a reason why they should trouble themselves about a matter so remote from their occupation.

Suppose we go somewhat into detail and ascertain if a working knowledge of chemistry for the boiler room is desirable, if not absolutely necessary.

It will be conceded that as the steam generator and connections are constructed principally of steel and iron, it is important that the men in charge—and those holding subordinate positions, for that matter—should know what elements cause chemical changes in iron and steel, which impair them. So much has been written regarding pitting, corrosion and scale that it seems like a waste of time to mention them here, yet the statistical reports from year to year show that the greater number of dangerous defects in boilers are due to these causes; and it should be needless to state that if attendants understand the chemical properties of the feed water used in the boilers, and can apply a suitable reacting agent, such defects will be greatly reduced.

Your feed water may be hard, but what do you know about the proper method of treating it? Do you know that hard water causes scale, corrosion of the boiler tubes, foaming, waste of fuel due to scale, cost of removing tubes and removing scale? What do you know about hard water, anyway; what is it? There is not a shadow of doubt but that you should know, and should know what to do to eliminate the injurious properties of the water.

Corrosion can be prevented, but one must know what causes it, and what to do to stop the chemical action producing it. Here again a slight knowledge of chemistry is required. Is corrosion due to organic matter, or acid contained in the feed water? What causes steam-pipe corrosion? And what can be done to prevent it? There is a remedy for these evils, and the engineer should know what it is.

Fuels and their analyses are holding the attention of the more progressive engineer, and rightly so. Today the demand is greater than ever before that fuel be purchased not by the ton, but according to its heating capacity. The standard method of sampling coal for analysis is well known, or if it is not, it may be obtained from works pertaining to the subject; also the method used in determining the calorific power of fuel by means of the calorimeter. If the engineer or fireman does not understand this important branch necessary to economical operation, he is behind in the race with progress.

Another essential in power-plant operation is the proper regulation of combustion. It is not sufficient to have a thorough knowledge of how to keep a boiler plant in first-class condition, or how to purchase fuel containing the greatest number of heat units at the most advantageous price, if the matter of fuel consumption is not taken care of. Here again chemistry is an important factor, as an occasional analysis of the chimney gases is necessary to determine the exact action of the combustion taking place in the furnace and the amount of combustibles escaping through the chimney, which latter can be prevented to a great extent if the proper amount of air were admitted to the furnace, and even if a man is away below the capacity required to make a flue-gas analysis, he will be a better fireman and find a real interest, even, in tending a boiler furnace if he has read "Faraday's Chemistry of a Candle," which a child can comprehend.

A Division of Labor

Much has been published of late about engineers' licenses and examinations, and if we concentrate our minds long enough we may be able to penetrate the passing clouds of smoke and find at least a little fire to justify our pains. The licensing of any particular trade or profession can have but one constitutional basis, "the safety of the public." Stripped of this it would be difficult indeed to adjust it so it would not interfere with our constitutional guarantee of life, liberty and the pursuit of happiness.

No new law designed to change a course of events was ever put into practice without serious opposition. Our license law has been no exception. The men whom it was intended to benefit most were the men who put forth the greatest obstructive efforts. However, the experimental stage of the license law has been passed. We should know definitely whether or not it is an equitable arrangement in whole or in part, and whether or not it is impartially applied, and if not, why not. And yet, after at least a dozen years' trial, we hear grumblings of discontent in Ohio, charges of favoritism in the Bay State, and meanwhile the boiler explosion goes merrily on, the last echoes from Maine being drowned in the rumblings from Texas, or some point in between.

A State examiner is described as being exceedingly amused to hear an applicant for a license admit that he would consult a boilermaker in case of trouble. We cannot refrain from asking, Why not? What is the boilermaker for? Is he making boilers today which are below the proper standard? If so, why not inspect him? Why not require that he secure a license after being properly examined and his knowledge of the business has been fully demonstrated? Why not keep our eye on the main point, the safety of the public, and concentrate our efforts to producing good boilermakers first, good boilers next, good inspectors to follow and good boiler operators as a finishing touch?

We cannot overlook the vast amount of good accomplished by the present system of State inspection of boilers, neither can we doubt the advisability of knowing whether or not our prospective engineers know that cylinder oil should be kept out of the boiler and water out of the engine, but that the proper amount of either in the right place is very desirable. Two or three dollars a day should not be expected to secure a man who is educationally fitted to design a steam boiler, engine, etc., and physically able and willing to shovel in the necessary coal and wheel out the ashes. Yet the lists of questions published as having been put to applicants for a license would indicate that that is just what we are expecting.

The boiler is unquestionably the most dangerous element in a steam-power plant. The flywheel separates occasionally, and the cylinder head takes periodical trips into strange quarters by way of diversion, but the most frequent to furnish trouble, and the most disastrous when it does so, is the boiler.

If a strong feeling that our license laws are not being equitably administered ever gains headway it is certain that radical changes will be made. As a suggestion for these possible changes, would it not be better reasonably to assure ourselves that the engineer is capable of operating and caring for his plant, to leave the design of the boiler to the boilermaker, with some supervision as to methods and material used, and the determination of the safe operation of the plant to the inspector?

Another formula for the rating of motor-car engines has been suggested by Rolls-Royce, Limited, well known automobile manufacturers, who propose that the engines shall be rated by the formula,

$$H.P. = 0.25\ (d - \tfrac{1}{2})^2\ N \sqrt{s}\ .$$

Here d denotes the cylinder diameter in inches, while s is the stroke, and N the number of cylinders.

Leather Belting Compared to Rope Drives*

By Harrington Emerson

C. W. Hunt, former president of the American Society of Mechanical Engineers, whose great engineering firm makes a specialty of rope transmission and ropes for transmission, says:

"Rope driving is not in direct competition with belting. Under the ordinary conditions of mill work, belting is by far the best and most economical material that engineers have yet found for the purpose. It is when belting does not work well, when the driving and the driven shafts are at an angle with each other, that rope drive finds its application."

In marked contrast with the large-minded statement of Mr. Hunt, as to the respective fields of belt and rope transmission, one of the leading rope-transmission companies makes claims for rope compared to belt, which are disingenuous when not false. These published claims are:

(1) "That the pulleys are narrower for the same power transmission."

This is true, but unimportant, as they are not cheaper.

(2) "As to distance and direction, rope-power transmission is practically unlimited."

No doubt the instance in mind is that of cable transmission to move street cars. Rope transmission several miles in length has been used for this purpose, but 85 per cent. of the power was consumed in pulling the rope without any load and some of the rope wore out in a few months. As an economical means of power transmission applied to long distance and change of direction, the rope drive has been abandoned. For power transmission with smallest friction loss and least trouble of operation, in all but the rarest cases, it will be found that belts or shafts or gearing are superior to rope.

(3) "The amount of power which may be transmitted is practically unlimited."

Not more than for any other installation. Seventy thousand horsepower is transmitted through the shafts of the latest Cunard steamers, 17,500 to each shaft. Increase of power is attained by increasing the number of ropes, but each rope added decreases the efficiency of transmission. The limit is soon reached.

(4) "The cost of installing and maintaining rope drives is much lower than for belts."

This is an error. The cost of installation may in certain cases be less, but maintenance costs are higher. Belt renewals, when belting is properly operated and looked after, are under 5 per cent. of the initial cost. Ropes wear out much more rapidly than belts and have but very little scrap value. Belts have a very large scrap value.

(5) "Transmission is more positive and steady."

Gearing is even more positive and steady. A locomotive tire has a more positive grip on the rail than an automobile tire on the road. One of the great superiorities of belting is that it is elastic and yields to varying strains, instead of breaking either itself or the installation.

(6) "Rope drives are noiseless."

So are belt drives.

(7) "No electrical disturbances are created."

If anyone has ever been troubled with electrical disturbances from belt drives, there is an easy and cheap method of eliminating them without resorting to rope drives.

(8) "There is no measurable loss in slipping."

There is a slight slip in belts, but including the slip, the power loss in one belt is less than in one rope. If positive transmission is absolutely required, chain drive or gears are better.

(9) "Alinement of shafting is not necessary."

If by this is meant that defective and careless installations can be permitted in rope drives, it is wholly wrong. Bitter complaints have been made of rope drives because of careless installations, often more serious for rope than for pulleys. An oval pulley is much less serious in belt drive than in rope drive.

(10) "Rope affords the cheapest and simplest method of distributing power to the different floors of a factory."

What about cutting out a floor? Friction clutches, always a source of annoyance, would have to be used with ropes. A belt is shifted to an idle pulley. Rope transmission is not simpler, although first cost of rope is cheaper than first cost of good belts, but rope drive (under comparable conditions) is not cheaper per horsepower actually transmitted.

(11) "Future additions to power may be made at small cost."

Also true for belting. If the pulleys and shafting will stand it, power can be doubled by doubling the thickness of the belt; much simpler than doubling the number of ropes or changing the grooves to take larger ropes.

(12) "Rope drives may be run out of doors and are not affected by heat, cold, moisture, dust or oil."

This is a broad claim, as heat, cold and moisture all affect the length of ropes. Oil and dust will rot ropes as fast as they will leather. Everyone knows that shoes made of leather are not affected by heat or cold within limits, nor by dust, and that a good oiling will soften the leather although it has been wet.

The following paragraphs are quoted from some of the highest authorities on rope transmission:

"There are two distinct systems of rope driving: the multiple, or English, system, and the continuous, or American, system; each under different conditions has its advantages. The multiple system is the simpler, consisting of one or more independent ropes running side by side in the grooves of the pulley. This system is especially adapted for the transmission of large powers in drives protected from the weather and where the shafts are parallel. This drive has the utmost security against breakdowns. Power can be increased by the addition of more ropes, and the rope always bending in the same direction has longer life than in the continuous system. Finally it is cheaper to install.

"In the continuous system one rope is wound around the driving and driven sheaves several times. A tension carriage automatically takes up the slack which may occur from stretch of rope or inequalities of load.

"The continuous system is more versatile, especially adapted to vertical and quarter-turn drives, where shafts are at an angle to each other, where rope is exposed to weather, and in any special case of complicated transmission.

"The belief is false that ropes of the same diameter will exert more horsepower with the continuous than with the multiple system.

"To limit the disintegration of rope, the diameter of the sheave should be made as large as practicable; not less than 36 times that of the rope, and, when space and speed of shaft will permit, 40 diameters should be used as a minimum. Experience has shown that in general work the best results are obtained with a V-shaped groove whose angle is 45 degrees as a runway on the sheave.

"Fortunately, wooden pulleys have almost disappeared. Owing to the impossibility of making a wooden sheave of uniform density throughout, some portions of the sheave would wear more than others, causing not only uneven running, but leaving ridges and rough places that quickly wore away the outside fibers of the rope.

"Wire rope is well adapted to the transmission of large powers to great distances, but its rigidness, great weight, and rapid destruction due to bending, unfit it for mill service. Wire ropes have proved unsatisfactory on drives on short centers and high velocities.

"Cotton rope is not durable; is injuriously affected by the weather, so that for exposed drives it is absolutely unsatisfactory. It is difficult—almost impossible, to splice it uniformly, and even the best quality of cotton rope is inferior in strength.

"A good transmission is the product of the most earnest and intelligent study.

"When spliced the essential points are:

"(1) The diameter must be absolutely the same as that of the original rope.

*Paper presented at the annual meeting of the Leather Belting Manufacturers' Association, November 17, 1908.

"(2) It must be smooth and free from lumps.

"(3) The original lay and strands of yarn must be disturbed as little as possible.

"(4) Where several strands are rejoined, each fastening or tuck must be made in such a manner as to prevent its wearing away and the rope unstranding.

"Beware of the old sailor who has been splicing ropes all his life, and, of course, 'knows it all.' His ship splice is fatal to transmission, nor have we yet seen any coupling device which is satisfactory.

"The most economical speed for a rope is 4000 to 4500 feet per minute; for while the amount for which the rope is capable increases with the velocity up to the rate of about 5000 feet per minute, it is equally true that the wear increases directly with the speed, because the greater the velocity the more bending and surface wear the rope must sustain."

Life of Ropes

The average life of a rope on a properly designed drive is from eight to ten years. On long vertical drives (the distance between shafts being 100 feet) 1½-inch diameter rope, running at a speed of 7200 feet per minute, transmitting 500 horsepower, has worked on an average of 20 hours a day for six years, and it still is in a very fair condition.

To show the opposite effect of high speeds on horizontal drives, thirty-two 2-inch ropes, running at a speed of 7100 feet per minute, transmitting 2000 horsepower, with driving shafts 16 feet in diameter, have failed after a life of eight or ten months, working night and day.

Large or Small Ropes

A small number of large ropes, if the smallest sheave is of sufficient diameter, is the better practice. As the number of splices is lessened the number of chances of failure is decreased. The greater wearing surface of the large rope adds to its life, and as small ropes are more easily broken, accidents are more likely to follow their use.

Tight ropes cause heating of the journals owing to the contraction of the ropes on damp days. Extremely slack ropes have a tendency to jump from the groove with variations of load.

In a continuous drive whose shallow grooves had become clogged with a cement of grease and dust, the rope jumped from the sheave, thereby demolishing the drive.

In the construction of a rope sheave and the turning of the groove too much care cannot be taken to secure the same pitch line in each groove.

In the continuous system, variations in the pitch line will cause a creep in the rope, and in badly turned grooves this creep can be noticed to travel from one groove to another. In the multiple system, irregularities in pitch line are shown by certain ropes being taut on the slack side, and slack on the driving side. This feature may exist from other causes than variation in pitch; as, for instance, a new rope placed on drives with older ones is larger in diameter than its companions and does not settle so far into the grooves. The slightest roughness on the surface of the groove is fatal to the life of the ropes.

Tension carriages. It is bad practice to require one tension sheave to serve an extreme number of ropes, better results being obtained in large drives by using two or more tension carriages.

In the continuous system the tension varies somewhat in the different laps of the rope, the sag being greater in the inside ropes. As the slack shifts from one rope to another, the rope slips in the groove and an unequal action, technically known as differential, is produced throughout the drive.

Further objections to the use of a single-tension sheave on large drives, are that a failure in any part of the rope must necessarily shut down the entire drive, and also the breaking of a long rope increases the chance of wrecking the machinery.

By dividing a continuous drive into two or more separate lengths of rope, each with its own tension carriage, these disadvantages are not only avoided, but many benefits of the multiple system are secured.

The element of danger which has always surrounded the continuous drive, and the liability of putting the drive out of service by the breaking of one rope, have been the system's greatest stumbling blocks.

"The ideal rope drive is one having a separate tension sheave for each lap of the rope, but, owing to the extreme cost and clumsiness of such an arrangement, it is impracticable. It is well to strike a happy medium between the two extremes and so design the drives, that if one rope should fail it may be quickly removed and operations continued with the remaining rope or ropes."

The American Manufacturing Company transmits 1000 horsepower as follows:

Engine flywheel to engine-room shaft, 1000 horsepower through twenty 1¾-inch ropes, multiple system.

The engine-room shaft transmits through two sets of sheaves.

(a) Four hundred horsepower by means of eight 1¾-inch ropes.

(b) Six hundred horsepower through twelve 1¾-inch ropes.

The distance from the engine-room shaft to the main-mill shaft is 225 feet, and the multiple-system rope drive is supported on ten idler sheaves.

From the mill main shaft 100 horsepower is delivered to the ground-floor main shaft, 40 feet away, through three 1¾-inch ropes, multiple system.

To the fifth floor, 150 horsepower is transmitted by a five-wrap continuous drive of 1½-inch rope.

To the fourth floor, 75 horsepower by a four-wrap continuous drive of 1½-inch rope.

To the second and third floors, 274 horsepower is transmitted by continuous system, through eight wraps to the second floor, and four wraps to the third floor, 1¾-inch rope.

There are two justifications for this rope-drive installation:

(1) The concern itself manufactures and installs rope drives and uses its own rope drive as a working exhibit.

(2) The distribution of the power. There is 1000 horsepower supplied by one engine, of which 400 horsepower is transmitted a short distance and 600 horsepower is transmitted 225 feet.

For this distance neither chain nor belt drive is suitable. On the other hand, the distance is too short for economical electric drive.

Instead of the above, any one of the following might have been installed:

(1) Separate oil, gas or steam engines.

(2) Central engine, steam, gas or oil, with shaft drive.

(3) Central engine, steam, gas or oil, with wire-rope drive.

Which of these nine different possible installations is best, depends on circumstances.

A rope drive must be carefully and accurately installed or it will not work at all. A belt drive can be put up in the old English fashion, so abnormally as to be a disgrace, yet a whole nation of leading mechanics do not know that it is not all right.

The transactions of the American Society of Mechanical Engineers contain many references to the unsatisfactory working of rope drives and their replacement by long shafts or belts.

A. C. Hobbs mentions a case in which a manila rope, driving across a yard 60 feet wide, worked sometimes very well and sometimes very badly, and so often badly that it had to be replaced by a 2¾-inch shaft. W. E. Partridge states that formerly rope drive was largely used at Proctor, Vt. In one case the distance was 275 feet, the angles very sharp, 45 degrees up a hill. The rope drive failed completely, owing to disastrous whipping in the wind, and was replaced by a shaft. He states that there is only one rope transmission left in the town.

Samuel Webber, life member of the American Society of Mechanical Engineers, and a distinguished hydraulic engineer, describes a return to a leather belt transmitting 135 horsepower.

In belt drives it has always been found very difficult to subdivide the power from one shaft to another between two belts running on different pulleys. When such drives have been installed, the superintendent or foreman of the shop often removes one of the belts on the ground

that more power and speed can be obtained in that manner. The reason is plain. Unless the two driving pulleys are exactly of the same diameter, and the two driven pulleys are also of exactly the same diameter, there is a different ratio of transmission. One of the belts has to slip. The other belt must not only do all the work, but in addition supply the power to make the other belt slip. Something similar, but not as bad, occurs if the pulleys are absolutely exact, but one of the belts is more elastic than the other. The stiffer belt carries most of the load. It is this division of the power between several grooves in rope transmission which interferes so seriously with the efficiency of rope drives. The rope generally runs in a V-shaped groove so as to bear tightly on the two sides, but not on the bottom of the groove. Assuming that all the grooves are exactly true in size and diameter, the rope is not always true, as new pieces may have been spliced in. If all the ropes do not run with the same diameter, if any one part of the rope stretches more than any other part, the stiffer rope or the rope running on a larger diameter drags an undue share of the load and rapidly wears out, since the destruction of the rope increases rapidly as the tension is increased. It is well-nigh impossible to install and maintain a multiple drive in perfect condition, and the larger the number of ropes the more difficult the problem. To transmit 140 horsepower would require, under the English system of separate ropes, ten ½-inch ropes, or seven 1¼-inch ropes, or five 1½-inch ropes, or three 2-inch ropes. Any of these installations might cost less than a 30-inch belt running 3500 feet per minute, but 1 per cent. per annum of first cost would replace the belt, which even at the end of forty years would still have a very large scrap value; while 20 per cent. per annum of first cost would have to be set aside to replace the ropes.

A well known authority on rope drives is Arthur Holmes Morse, who writes in the *Harvard Engineering Journal*, page 205, 1903, as follows:

"Under the multiple system a rope can be spliced and put on the sheaves in from 2 to 4 hours."

The theoretical perfection of the continuous drive is realized only with a drive of one wrap. The greater the number of wraps the more irregularity of action, and in drives of a large number of wraps, 15 or 20, there is a progressive and nearly uniform decrease in tension, the slackest ropes sagging two or three times as much as the tightest, with a more than proportionate difference in tension.

Lack of uniformity in the sag of ropes is very serious when ropes are led around a corner, as the guiding sheave cannot be correctly set for all the wraps. Imperfections of installations also affect rope drives injuriously. Wabbling sheaves cause lateral vibrations in the rope, always annoying, more violent and more dangerous at high speeds. A still worse defect is eccentricity of sheaves, which alternately jerks and slackens the rope at every revolution. In vertical drives the incessant jerking is speedily destructive to the rope. This particular defect is by no means rare, even in machinery made by manufacturers of good reputation.

Inequality in the diameter of different grooves in the same sheave is another cause of short-lived ropes. Slipping must occur. The amount of the slip is great. A difference in diameter of 1/16 of an inch in two 48-inch sheaves running 300 revolutions per minute will cause a slip of more than half a mile per day. The increased wear is not, however, the worst of the slip, but the abnormal tightness in some wraps and the slackness in others. If the sheaves are less than 40 times the diameter of the rope, its life is short.

The elasticity of a rope is something quite different from the elasticity of a belt. A wide belt is just as elastic for its load as a small belt, but in rope drives with several wraps, elasticity disappears. An illustration of this occurred in a large plant whose main business was the manufacture and installation of rope drives. One line shaft was driving the other by leather belt and pulleys which had worked perfectly for many years. It looked bad, however, for a rope-transmission plant to be using belting, so a rope drive of several wraps was substituted. The shaft immediately broke in the coupling. It was repaired, and again broke in the same place. The explanation given for the recurring breaks was that under the great variations of load which occurred, the belt acted as a spring, but the tightest wrap of the rope could not yield, transmitting the shock rigidly to the sheaves and shaft, which not being strong enough, gave way. The belt drive was reinstalled and there was no further trouble.

Centrifugal Pumping Units

By S. Rice

Centrifugal pumps operated by vertical engines meet the demand for a compact and reliable unit. Such units are found satisfactory for use as circulating pumps for surface or barometric condensers, for hot-water heating systems, for mine service, for general contractors' use, as in the draining of pits, and other service of this kind. For industrial plants requiring the rapid circulation of water, such as paper mills, tanneries, etc., or for operations that necessitate its ejectment, as in dry-dock work, dredging, etc., this type of pump, up to its capacity, is particularly adapted; and when water or other fluids are filled with wood chips, bits of bark, stringy material, gritty substances and the like, as they are apt to be under the conditions mentioned, these units offer an easy solution of the problem. They are built for any capacity and condition of service within the range of their

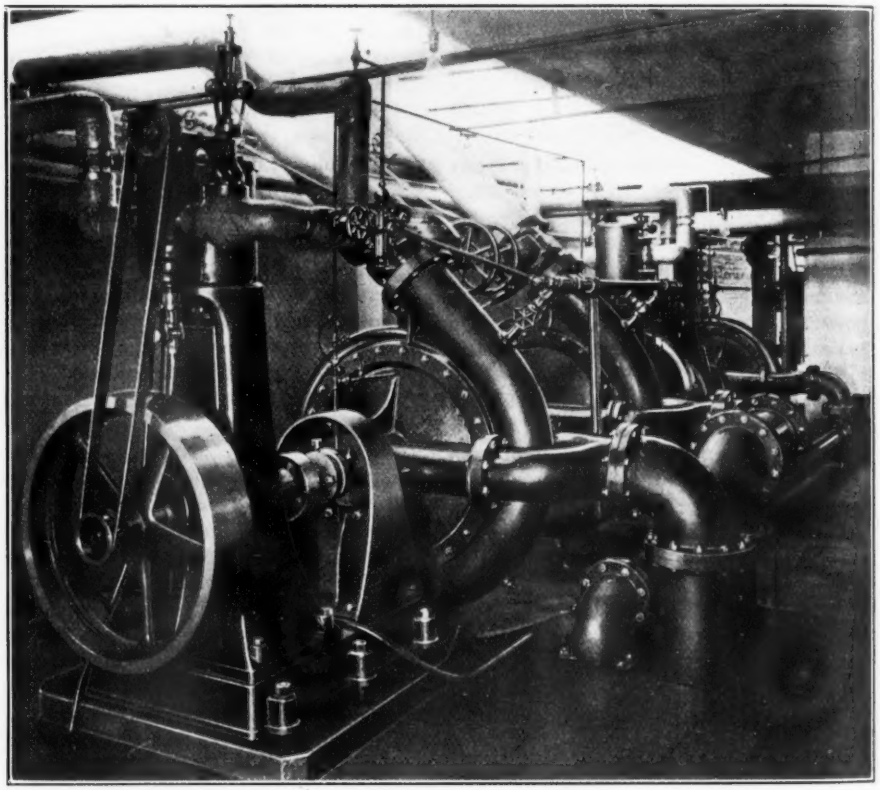


FIG. 1. "A B C" ENGINES DIRECTLY COUPLED TO ALLIS-CHALMER PUMPS

adaptability, from 400 gallons per minute up.

The pump is of the double-suction type, so arranged that water enters the pump from both sides, at and directly opposite the center of the revolving impeller, forming a balanced suction. It is bolted to and supported by a hood which is fastened to the base plate. This arrangement allows the pump to be rotated about its axis so that the direction of suction and discharge may be arranged at any angle within certain limits. The side covers are bolted to the casing, which is snail-shell shaped and made of close-grained cast iron of suitable thickness and bored and faced. The openings closed by these covers are slightly larger in diameter than the impeller, so that the latter, with its shaft, may be easily removed. The suction elbows are a part of the side covers.

The single- and double-cylinder, vertical, inclosed, self-oiling engines used with the pump are especially adapted for this work. They operate continuously at high speeds for long periods without attention, which is rendered possible by the system of lubrication employed. At the base of the engine is located a small pump which delivers to each moving part a stream of oil. For this service, the engines are ordinarily fitted with throttling governors, in order that the speed may be varied to suit conditions. The engines are fully inclosed, but the inclosing panel is readily removed and access given to the working parts.

These units are furnished with either liquid-lubricated or special ring-oiling bearings, according to the requirements of the service. The former are located in the covers and consist of several composition rings in halves, being so arranged that oil, grease or water can be used as a lubricant. Bearings of the latter type have an oil reservoir and are mounted on brackets cast on the side covers or have pedestals resting on the extended baseplate. The advantage of this self-contained, ring-oiling design is to eliminate all danger of grit or other foreign matter working into the bearings, and it permits the pump to be operated for a long period of time with no attention farther than the occasional filling of the oil reservoir.

Both types of bearing are lined with babbitt metal expanded in place, bored and scraped to fit the shaft and provided with suitable channels to effect an even distribution of the lubricant over the entire surface of the journals. The stuffing boxes through which the shaft passes are so constructed as to provide a water seal, which prevents air from being drawn into the pumps and thereby destroying the vacuum and impairing the suction.

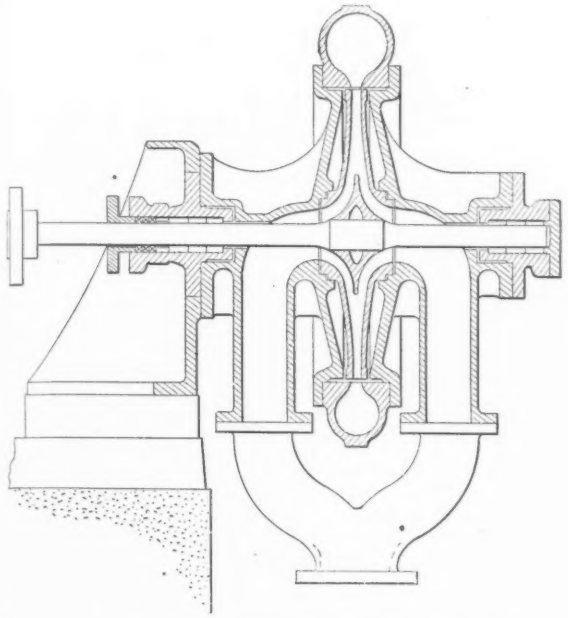


FIG. 2. ORDINARY LIQUID LUBRICATED BEARING

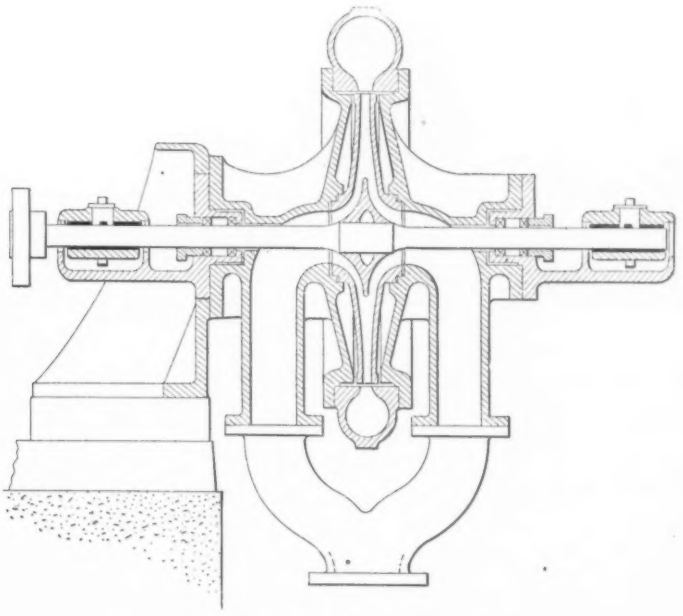


FIG. 3. MAIN BEARINGS AWAY FROM CASING

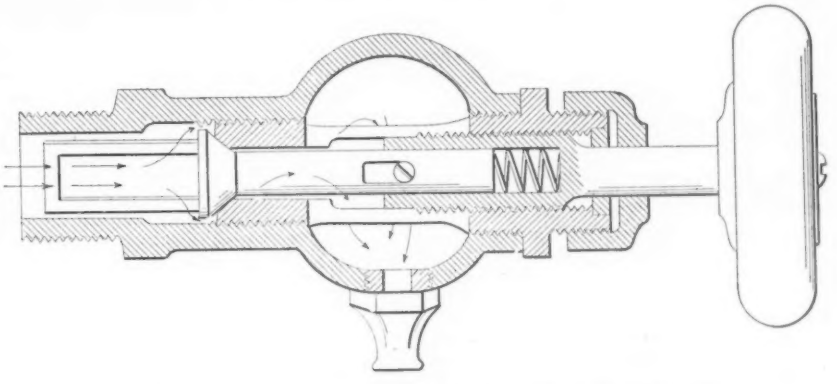
To find the weight of castings, multiply the cubic inches by 0.27 for iron, 0.29 for steel and 0.30 for brass.

The Stulp Automatic Regrinding and Cleaning Gage Cock

The Stulp automatic regrinding and cleaning gage cock is so made that every time the valve is forced from its seat to blow through the gage, it makes one and one-half turns on its seat before leaving its seat, owing to the slot in the sectional valve stem; and in closing the valve the action is *vice versa*. This is shown in the illustration. This one operation gives the valve disk three complete turns on its seat every time the gage cock is used.

The cleaner at the end of the valve, making the same number of turns, cleans its way to the boiler or water column, thereby insuring a positive opening to either.

This gage cock is neat in appearance, strong and durable, easily taken apart and all parts are interchangeable. It is manufactured by the Automatic Safety Water Gauge Company, Muskegon, Mich.



STULP AUTOMATIC REGRINDING AND CLEANING GAGE COCK

New York Association No. 44, N. A. S. E., held its annual smoker on Saturday evening, November 21, at its meeting rooms, 2126 Broadway, New York. There was the usual large attendance. An enjoyable entertainment was given by the "bunch," assisted by excellent local talent. Refreshments were served.

Local No. 20 of New York, the International Union of Steam Engineers, held its annual entertainment and ball Saturday evening, November 21. The large hall was crowded to its fullest capacity, and the event was a decided success. A good vaudeville program was followed by dancing.

Business Items

The L. J. Wing Manufacturing Company, 90 West street, New York, sends us a list of sixteen recent orders for Wing turbine blowers and nine orders for Wing disk fans.

Frank Thompson has purchased the interests, etc., of Richard Thompson in the steam-specialty firm of Richard Thompson & Company, 126 Liberty street, New York. The business, we are informed, will be continued on a much larger scale than heretofore.

Richard Thompson, for many years connected with the steam-specialty firm of Richard Thompson & Company, has severed his connection with that company, but will continue in the same line of business. Mr. Thompson has become associated with the L. J. Wing Manufacturing Company, 90 West street, New York.

The Minneapolis Steel and Machinery Company has secured the contract to install a new power plant for the Manhattan City and Interurban Railway Company, of Manhattan, Kan. The installation will include an 18x36 heavy-duty Twin City Corliss engine, two 66-inch by 18-foot horizontal return-tubular boilers, one 200-kilowatt direct-current generator, switchboard, feed-water heater and purifier, boiler feed pump, etc.

The Imperial Grain and Milling Company Toledo, Ohio, installed Buckeye boiler skimmers in its two boilers, and reports that before the skimmers were installed it was necessary to blow off the boilers several times a day, and n seasons when the water was muddy, every hour, causing a great waste of water. Now they blow off every hour and a half when the water is muddy, with very little waste, open the boilers once a month instead of every week, and the boilers are also free from scale.

Scarcely more than six months after the publication of the large first edition of their catalog, entitled "The 'Swartwout' Cast Iron Exhaust Head and Centrifugal Steam Separators," the Ohio Blower Company, of Cleveland, Ohio, was obliged to go to press with a second edition equal in size to first. The cause is not far to seek, for this catalog has been frequently referred to as "the finest in the steam specialty field." It is now ready for distribution to those who were unable to obtain copies of the first edition.

The Henry Steam Flue Cleaner Company, Ashland, Wis., has received a letter from H. L. Wilson, president of the Newton (Iowa) Ice and Cold Storage Company, in which he says: "We have had your cleaner in constant operation since May 15. We attached it to a new boiler and use it three or four times every twenty-four hours, and our engineer informs us that our flues are as clean as when new. He also says it is the greatest labor saver he ever saw. We are highly pleased with it. When we install another boiler, we shall not consider it complete without a 'Henry' flue cleaner."

Steam users are beginning to realize and appreciate more and more the economic advantages of soft, clear water for boiler feed. Those not so fortunate as to have an available supply which does not cause scale or corrosion, or both, are installing water softening and purifying systems to remove the objectionable substances from the water before feeding into the boilers. William B. Scaife & Sons Company, of Pittsburg, Penn., manufacturers of the Scaife and "We-Fu-Go" water-softening and purifying systems, report an extremely satisfactory years' business, and recent contracts aggregating 9000-horsepower for these systems.

Last June the Isthmian canal government invited bids for a large quantity of bronze globe and angle valves, fitted with seats and disks capable of being removed. Considerable competition resulted and after the authorities at the Isthmus and at Washington had carefully considered the bids, they decided, a few days ago, to place the order, comprising upward of seven thousand valves, in sizes ranging from ¼ to 3 inches, inclusive, for the Lunkenheimer "Renewo" renewable seat and disk regrinding valve. These valves are guaranteed for 200 pounds working pressure and are manufactured by the Lunkenheimer Company, of Cincinnati, Ohio.

Another large manufacturing plant, that of the Estey Organ Company, in Brattleboro, Vt., is to install electric drive throughout the works. This is the largest organ factory in he world. They have just placed with the Crocker-Wheeler Company, of Ampere, N. J., an order for 57 induction motors, ranging from to 75 horsepower, together with seven transformers and a switchboard. Current will be purchased from the Connecticut River Power Company. Some of these motors will be used for driving individual machines and others for driving line shafting. The proper subdivision of the plant into groups and individual machines was a nice problem and was successfully worked out by the engineers of the Crocker-Wheeler Company.

The Blackburn-Smith feed-water filter and grease extractor has been chosen for the new colliers, "Mars," "Hector" and "Vulcan," now being built for the United States navy by the Maryland Steel Company. These ships have the highest class of equipment, and every possible protection. The filters are to be placed in the feed lines, so that every drop of water entering the boilers, is subjected to the double filtration, characteristic of the Blackburn-Smith filter. It is figured that by removing the oil and grease particles from the condensation, the filters will repay their cost in a short time by decreasing boiler repairs, and increasing fuel economy. These filters are also used for protecting the boiler of stationary plants from floating particles of oil, grease, mud, etc., in the feed water. They are made by James Beggs & Company, 106 Liberty street, New York, who are distributing an interesting booklet on feed-water filtration.

W. B. McVicker has resigned as vice-president and Eastern manager of the Dearborn Drug and Chemical Works. Mr. McVicker was connected with this company for many years, having opened and developed all of the territory east of Chicago, including Cuba. His many friends and acquaintances will be interested to know that he has incorporated the W. B. McVicker Company, with offices in the United States Realty building, 115 Broadway, New York. A new and complete laboratory and factory are in course of construction and will be completed about December 1. They will have exceptional facilities for general analytical work, and the manufacture of high-class products. A specialty will be made of scientific preparations for treating boiler feed waters and hydraulic systems, also high-grade lubricants. The personnel of the company includes Charles M. Eddy, Albert E. Carpenter, Joseph F. Hammill, William J. Schatz, G. Frank Duemler and Frank J. Zink; names well known in business and professional circles; men who have long been associated with Mr. McVicker.

"Surface Condensers" is the title of a 24-page, 8x10½-inch booklet just published by the Wheeler Condenser and Engineering Company. The contents include a chapter on the conomy of running condensing, another on the advantages of the several types of condenser, followed by a description of the Wheeler surface condensers, with some remarks on the relative advantages of rectangular and cylindrical shells. The Volz combined feed-water heater and condenser, in which some of the tubes serve as a primary heater, is next described, after which there is a section on turbine-condenser outfits. The final part of the catalog is devoted to notes and suggestions on the installation and operation of surface condensers. The illustrations, of which there are a large number, show not only the various types of Wheeler "Admiralty" and Wheeler-Volz surface condensers of the rectangular and cylindrical patterns, and water-works condensers, but also include a considerable number of the largest steam-power plants in this country. This booklet is one of a series of engineering treatises which the Wheeler Condenser and Engineering Company is distributing.

New Equipment

The Mesa (Ariz.) Electric Light and Power Company is erecting a new substation.

The Parkersburg (W. Va.) Ice Company will rebuild its plant, recently destroyed by fire.

G. E. Oliver, box 88, Fredonia, Kan., contemplates installing a small ice and electric plant.

The city of Terrell, Texas, will construct an electric-light plant. $15,000 bonds have been issued.

The municipal electric-light and water-works plant at Ottawa, Kan., will be enlarged.

The Pacific Gas and Electric Company, San Francisco, Cal., will erect two new power houses.

The North Adams (Mass.) Gas Light Company, will build a new plant at a cost of $100,000.

Morris & Company, Chicago, Ill., will erect a seven-story cold-storage plant to cost about $750,000.

The Geneva-Seneca Electric Company has begun the erection of a new power station in Geneva, N. Y.

The Village of Tiro, Ohio, is contemplating the installation of water works. Charles Mc Connell, clerk.

The Mutual Ice and Cold Storage Company, Kansas City, Mo., will erect a $15,000 cold-storage building.

The Pablo Beach (Fla.) Development and Power Company is planning, it is said, to construct an electric-light plant and water-works system.

The city of Uniontown, Ky., will put in a water-works system and would like estimates on equipment. For full information, address G. F. Cecil, Uniontown.

Help Wanted

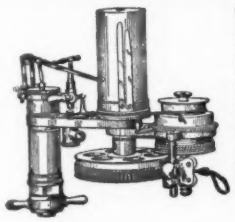
Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

You Could Almost Hear A Pin Drop

where New Process Rawhide Gears and Pinions are used. They make machinery run quietly—and they last for years. Catalog?

THE NEW PROCESS RAW HIDE COMPANY,
SYRACUSE, NEW YORK.



WHAT! NO INDICATOR?

Don't you know that I can give you a fine up-to-date outfit, new, from $25 00 up, and that I will let you pay a part of it acting as my agent in your spare time?

I will give you a thorough course of indicator instruction with a fine indicator to practice with for $5.00 per mo. Catalog?

Extra ¼ in. Area Cyl. for Ammonia, Gas Engine and high pressure work.

A. C. LIPPINCOTT, Newark, N. J.

THE BRISTOL COMPANY
MANUFACTURERS OF
BRISTOL'S RECORDING PRESSURE
AND
VACUUM GAUGES
AND

a complete line of recording instruments for pressure, temperature and electricity.

THE BRISTOL COMPANY
Waterbury, Conn.
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DON'T LET $4.80

Stand between you and healthy, long-lived, dependable belts.

Ask your dealer for a box of STEPHENSON Bar Belt Dressing, and see how quickly and gratefully your belts will respond to good treatment.

The results will delight your heart and your check book.

Be sure our registered Trade-Mark, The man with the Cog-Wheel Face, is on each Pound Stick.

Don't confuse the Brands:

RED Label Brand for Leather Belts
GREEN Label for Rubber and Canvas

$4.80 for a 12-lb. box

Of Dealers Everywhere, or

STEPHENSON MFG. CO.
ALBANY, N. Y.

The Contest Between Two of the Bills is Over

But that old *Coal Bill* is still after your *Dollar Bill*. The thing to do now is to elect a

Murray Corliss Engine

into the place of that steam-eater that is gnawing away at your roll of good money.

Write the

Murray Iron Works Co.,
Burlington, Iowa.

Mason Reducing Valves SAVE COAL

by keeping steam pressure just where you want it. Write for Catalog.

The Mason Regulator Co., Boston, Mass.

FLINN DIFFERENTIAL STEAM TRAPS

Save their Cost by Increasing Engine Efficiency.

THE EDWARD P. ALLIS COMPANY, Milwaukee, Wis.
[AFTER SELLING OVER 500 FLINN TRAPS.]

Replying to yours of the 17th inst., we would say that we have used the FLINN DIFFERENTIAL STEAM TRAP for a number of years, practically since its first introduction, and have found it the most general satisfactory trap we have ever used.

Yours, truly,
[Signed] THE EDWARD P. ALLIS COMPANY,
By Irving H. Reynolds.

DESCRIPTIVE CIRCULAR ON REQUEST.

RICHARD J. FLINN, West Roxbury Station, Boston, Mass.

FOR SALE BY ALL SUPPLY HOUSES

50 CTS. PER STICK, $5.00 PER DOZEN

It is the only article that will prevent sparking. Will keep the Commutator in good condition and prevent cutting. Absolutely will not gum the brushes.

It will put that high gloss on the Commutator you have so long sought.

K. McLennan & Co., Sole Manufacturers
411-130 Dearborn St., Chicago, Ill.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

WANTED — By prominent engineering house on the North Pacific coast, a practical mechanical draftsman. One acquainted with power plant design preferred. Splendid opening for one who is in earnest. Address, giving full particulars as to qualifications, salary wanted, etc. Box 65, POWER.

AGENTS to sell one of the best known and widely advertised shaking grates on the market. Exclusive territory granted to anyone who can make good. Liberal commission. Perfection Grate Co., Box 1081, Springfield, Mass.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

SITUATION WANTED as salesman; six years' power plant experience by technical graduate; 28 years old. Address "A. J.," POWER.

CHIEF ENGINEER having 20 years' experience with modern engines, boilers and a.c. and d.c. generators, desires position. Can give references and good economy. Box 61, POWER.

PRACTICAL MACHINIST and mechanical engineer desires position as master mechanic or superintendent; Western States preferred; holding similar position but wish to change. Box 67, POWER.

CHIEF ENGINEER of large industrial plant desires change; active and alive, an expert with indicators and testing apparatus, can keep operating expenses at proper figures. Box 27, POWER.

WANTED—Position by young man as oiler in large power plant to gain experience; best references. At present employed as engineer in small plant; good reason for changing. Colorado or California preferred. F. C. Prager, Box 623, Las Vegas, New Mexico.

POSITION WANTED as chief engineer; experienced with all kinds of engines, steam turbines, a.c. and d.c. generators, motors and switchboards, boilers and pumps; I can get results and furnish the references; have been seventeen years in the mechanical and engineering business. Box 9, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

IF YOU DESIRE to learn the latest improvements in steam boilers, correspond with the Detroit Water Tube Boiler Co., Detroit.

ENGINES AND BOILERS, ⅛ to 2 h.p., engine castings in sets. Models and general machine work. Sipp Electric and Machine Co., Paterson, N. J. Catalog 4c.

ENGINEERS read and assist fellow engineers by handling latest book on steam boilers; liberal commission. Stephen Christie, 171 La Salle St., Chicago.

PATENTS—H. W. T. Jenner, patent attorney and mechanical expert, 608 F St., Washington, D. C. I make an investigation and report if patent can be had, and exact cost.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-examiner, U. S. Patent Office, McGill Bldg., Washington, D. C.

ENGINEERS AND FIREMEN—Send 10 cents in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2703 Cass Avenue, St. Louis, Mo.

AN ESTABLISHED MANUFACTURER, owning a large foundry and machine shop with modern equipment and 15-ton crane, desires to get some young blood and a good line of heavy iron machinery, engines or tools to manufacture. Address, with particulars as to line offered. Box 64, POWER.

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—3″x7″ Corliss engine, highly finished. 2415 Mission St., S. S. Pittsburg, Penn.

FOR SALE—20x48 Wheelock engine and two 72″x18′ high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

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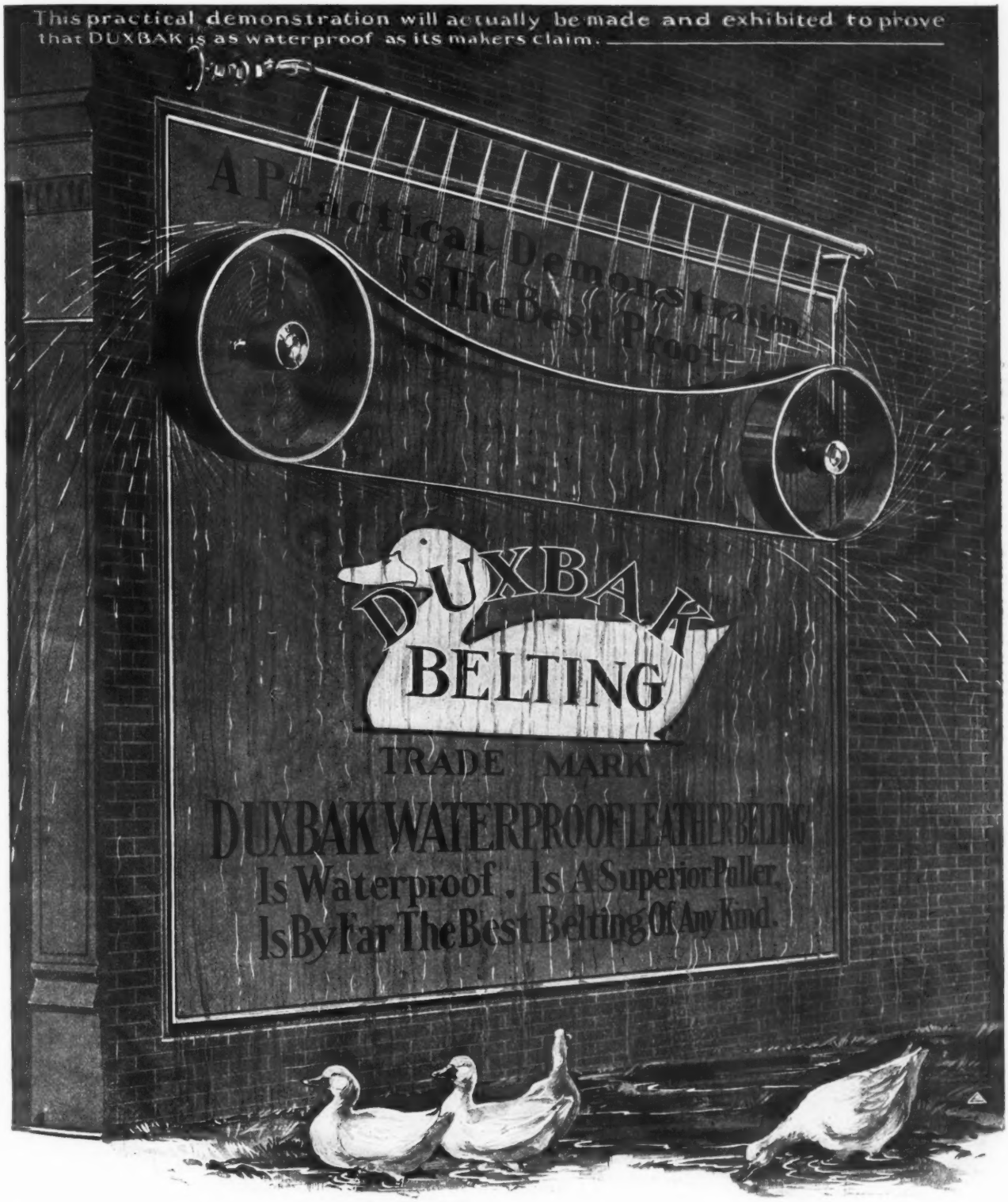
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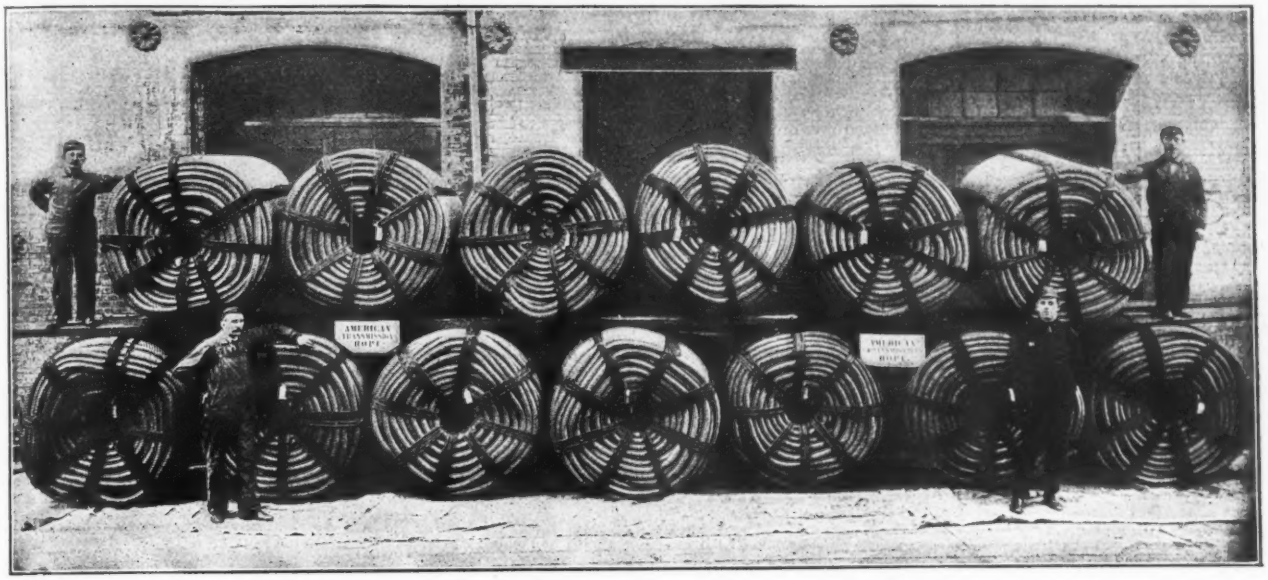

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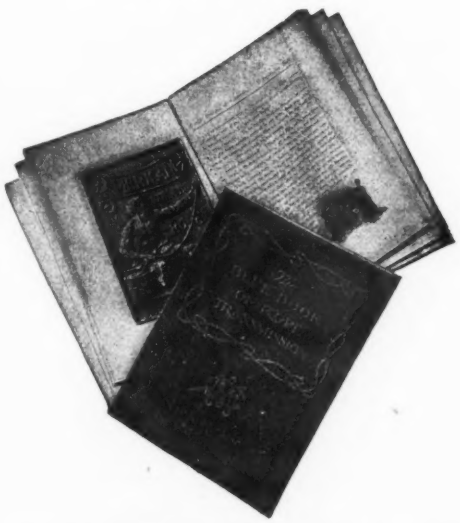

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Beggs & Co., James, New York.
Buckeye Engine Co., Salem, O.
Buffalo Forge Co., Buffalo, N. Y.
Chuse Engine & Mfg. Co., Mattoon, Ill.
Clark Bros. Co., Belmont, N. Y.
Cooper Co., C. & G., Mt. Vernon, Ohio.
Crowe, Paul L., Jersey City, N. J.
De La Vergne Mach. Co., New York.
Engberg's Electric & Mechanical Works, St. Joseph, Mich.
Erie Mfg. & Supply Co., Erie, Pa.
Fishkill Landing Machine Co., Fishkill-on-the-Hudson, N. Y.
Fitchburg Steam Engine Co., Fitchburg, Mass.
Green Fuel Economizer Co., Matteawan, N. Y.
Greenfield, Steam Engine Works, Harrison, N. J.
Griffith & Wedge Co., Zanesville, O.
Griscom-Spencer Co., New York.
Harrisburg Fdry. & Mach. Works, Harrisburg, Pa.
Harris Steam Engine Co., Wm., A., Providence, R. I.
Hewes & Phillips Iron Works, Newark, N. J.
McIntosh, Seymour & Co., Auburn, N. Y.
Mesta Machine Co., Pittsburg, Pa.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Morris Machine Works, Baldwinsville, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Phoenix Iron Wks. Co, Meadville, Pa.
Providence Engr. Works, Providence, R. I.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Riverside Engine Co., Oil City, Pa.
Rollins Engine Co., Nashua, N. H.
Russell Engine Co., Massillon, Ohio.
St. Louis Iron & Mach. Works, St. Louis, Mo.
Skinner Engine Co., Erie, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Vilter Mfg. Co., Milwaukee, Wis.
Westinghouse Mach. Co., Pittsburg, Pa.
Wheeler Condenser & Engineering Co., New York
Wickes Bros., Saginaw, Mich.
York Mfg. Co., York, Pa.

Exhaust Heads
Burt Mfg. Co., Akron, O.
Direct Separator Co., Syracuse, N. Y.
Gardner Governor & Separator Co., Quincy, Ill.
Hoppes Mfg. Co., Springfield, O.
Loew Mfg. Co., Cleveland, O.
Ohio Blower Co., Cleveland, O.
Patterson & Co., Frank L., New York.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Robertson & Sons, Jas. L., New York.
Standard Gauge Mfg. Co., Foxboro, boro, Mass.
Sterling Blower & Pipe Mfg. Co., Hartford, Conn.
Sturtevant Co., B. F., Hyde Park, Mass.
Whitlock Coil Pipe Co., Hartford, Conn.
Wright Mfg. Co., Detroit, Mich.

Fans, Electric
General Electric Co., Schenectady, N. Y.
Triumph Elec. Co., Cincinnati, O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.
Wing Mfg. Co., L. J., New York.

Fans, Exhaust
Anderson Co., V. D., Cleveland, O.
Buffalo Forge Co., Buffalo, N. Y.
C & C Electric Co., New York.
Green Fuel Economizer Co., Matteawan, N. Y.
Wing Mfg. Co., L. J., New York.

Feeders, Boiler
American Boiler Economy Co., Philadelphia, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Union Steam Pump Co. Battle Creek, Mich.

Feeders, Furnace
Ohio Blower Co., Cleveland, O.
Sterling Blower & Pipe Mfg. Co., Hartford, Conn.

Filters, Feed Water
Eclipse Feed Water Heater & Purifier Co., Oshkosh, Wis.

Filters, Oil
Beggs & Co., James, New York.
Burt Mfg. Co., Akron, O.
Flower Steam Specialty Co., Walter L., St. Louis, Mo.
Houghton & Co., E. F., Philadelphia, Pa.
Liberty Mfg. Co., Pittsburg, Pa.
Robertson & Sons, Jas. L., New York.
Standard Gauge Mfg. Co., Foxboro, Mass.
Wright Mfg. Co., Detroit, Mich.

Firebox Blocks
McLeod & Henry Co., Troy, N. Y.

Fittings, Ammonia
York Mfg. Co., York, Pa.

Fittings, Boiler
Lunkenheimer Co., Cincinnati, O.
National Tube Co., Pittsburg, Pa.
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Fittings, Pipe
Fairbanks Co., New York.
Lunkenheimer Co., Cincinnati, O.
McCrea & Co., James, Chicago, Ill.
National Tube Co., Pittsburg, Pa
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Valve & Fittings Co., Barberton, Ohio.
Pittsburgh Valve, Foundry and Construction Co., Pittsburg, Pa.
Trimont Mfg. Co., Roxbury, Mass.

Flanges
Ball & Wood Co., Elizabethport, N. J.
Chapman Valve Mfg. Co., Indian Orchard, Mass
Jefferson Union Co., Lexington, Mass.

Flanges, Forged Steel
American Spiral Pipe Works, Chicago, Ill.

Floats
Anderson Co., V. D., Cleveland, Ohio.
Hercules Float Works, Springfield, Mass.
Reliance Gauge Column Co., Cleveland, Ohio.

Floor Stands
Chapman Valve Mfg. Co., Indian Orchard, Mass.

Flue Gas Analysis Instruments
Pierce Co., Wm. B., Buffalo, N. Y.

Forges
Buffalo Forge Co., Buffalo, N. Y.
Wing Mfg. Co., L. J., New York.

Forgings, Drop
Williams & Co., J. H., Brooklyn, N. Y.

Forgings, Iron and Steel
Griscom-Spencer Co., New York.

Fuel Economizers
Green Fuel Economizer Co., Matteawan, N. Y.
Sturtevant Co., B. F., Hyde Park, Mass.

Furnace Tile
C-O-Two Furnace Co., Syracuse, N. Y.

The Good Times Are Here

Remember:

We carry the largest stock of goods in our line in this country.

Now is the time to prepare yourself for the demand that is sure to come.

Some are bound to be caught.

For just such an emergency, a complete stock will be found at our branch offices in Chicago and New York and factory in Boston.

When you need something in a hurry, try us and you won't be disappointed.

American Steam Gauge & Valve Mfg. Company

208-220 Camden Street, Boston, Mass.

New York, 26 Cortlandt St. Atlanta, 835 Equitable Bldg. Chicago, 7-9 So. Jefferson St.

Pittsburg, Frick Bldg. Annex.
Montreal, 444 St. James Street

San Francisco, Monadnock Bldg.
Los Angeles, 213 So. Los Angeles Street.

Furnaces, Annealing
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnaces, Forging
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnaces, Hardening
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnaces, Melting
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnaces, Smokeless
McClave-Brooks Co., Scranton, Pa.
Murphy Iron Works, Detroit, Mich.
Wilkinson Mfg. Co., Bridgeport, Pa.

Furnaces, Tempering
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Gage Boards
Standard Gauge Mfg. Co., Foxboro. Mass.

Gage Glasses
Chesterton & Co., A. W., Boston, Mass.
Garlock Packing Co., Palmyra, N. Y.
Johnson Co., Henry, Jersey City, N. J.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Standard Gauge Mfg. Co., Foxboro, Mass.
Sterling Lubricator Co., Rochester, N. Y.
Webster & Co., Warren, Camden, N. J.

Gage Testing Outfit
American Steam Gauge & Valve Mfg. Co., Boston, Mass.

Gages, Ammonia
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Standard Gauge Mfg. Co., Foxboro, Mass.

Gages, Draft
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Bristol Co., Waterbury, Conn.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Gages, Pressure
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Golden-Anderson Valve Specialty Co., Pittsburg, Pa.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Standard Gauge Mfg. Co., Foxboro, Mass.
Webster & Co., Warren, Camden, N. J.

Gages, Recording
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Bristol Co., Waterbury, Conn.
Ohio Injector Co., Wadsworth, Ohio.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Standard Gauge Mfg. Co., Foxboro, Mass.

Gages, Vacuum
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Standard Gauge Mfg. Co., Foxboro, Mass.

Gages, Water
Greene, Tweed & Co., New York.
Huyette Co., Paul B., Philadelphia, Pa.
Jerguson Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Ohio Brass Co., Mansfield Ohio.
Reliable Water Gauge Co., St. Louis, Mo.
Reliance Gauge Column Co., Cleveland, O.
Standard Gauge Mfg. Co., Foxboro, Mass.
Wright Mfg. Co., Detroit, Mich.

Gas Exhausters
Green Fuel Economizer Co., Matteawan, N. Y.
Ohio Blower Co., Cleveland, O.

Gas Producers
Broomell, Schmidt & Steacy Co., York, Pa.
Gas Machinery Co., Cleveland, Ohio.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Power & Mining Mach. Co., Cudahy, Wis.

Gaskets
American Goetze-Gasket & Packing Co., New York.
Carey Co., Philip, Cincinnati, O.
Detroit Leather Specialty Co., Detroit, Mich.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Home Rubber Co., Trenton, N. J.
Houghton & Co., E. F., Philadelphia, Pa.
Johnson Co., Henry, Jersey City, N. J.
Keeler Co., E., Williamsport, Pa.
Mechanical Rubber Co., Cleveland, O.
National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Stevens & Co., Chas. L., Detroit, Mich.

Gaskets, Copper
American Goetze-Gasket & Packing Co., New York.

Gaskets, Leather
Detroit Leather Specialty Co., Detroit, Mich.
Stevens & Co., Chas. L., Detroit, Mich.

Gaskets, Water Gage
Johnson Co., Henry, Jersey City, N. J.
Morse, R. F., Providence, R. I.

Gears
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
New Process Raw Hide Co., Syracuse, N. Y.

Generating Sets
American Engine Co., Bound Brook, N. J.
C & C Electric Co., New York.
Engberg's Electric & Mechanical Works, St. Joseph, Mich.
Foos Gas Engine Co., Springfield, Ohio.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Electric Co., Cincinnati, Ohio.

Governors, Pump
American Boiler Economy Co., Philadelphia, Pa.
Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Pittsburg, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Davis Co., John, Chicago, Ill.
Fisher Governor Co., Marshalltown, Iowa.
Gardner Governor & Separator Co., Quincy, Ill.
Mason Regulator Co., Boston, Mass.
Strong, Carlisle & Hammond Co., Cleveland, O.
Webster & Co., Warren, Camden, N. J.

Graphite
Carpenter & Co., W. D., New York.
Garlock Packing Co., Palmyra, N. Y.
Johnson Co., Henry, Jersey City, N. J.

Grate Bars
Salamander Grate Bar Co., New York.

Grates
Salamander Grate Bar Co., New York.

Grates, Chain Traveling
Green Engineering Co., Chicago, Ill.

Grates, Clinker Cutting
McClave-Brooks Co., Scranton, Pa.
Neemes Bros., Troy, N. Y.

Grates, Dumping
Beggs & Co., James, New York.
Martin Grate Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Neemes Bros., Troy, N. Y.
Salamander Grate Bar Co., New York.
Thacher & Co., George H., Albany, N. Y.

Grates, Rocking
Martin Grate Co., Chicago, Ill.
Salamander Grate Bar Co., New York.

Grates, Shaking
Martin Grate Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Neemes Bros., Troy, N. Y.
Robertson & Sons, Jas. L., New York.
Salamander Grate Bar Co., New York.
Thacher & Co., George H., Albany, N. Y.

Grates, Stationary
Neemes Bros., Troy, N. Y.
Salamander Grate Bar Co., New York.

Grease
Carpenter & Co., W. D., New York.
Cook's Sons, Adam, New York.
Dixon Crucible Co., Jos., Jersey City, N. J.
Harris Oil Co., A. W., Providence, R. I.
Houghton & Co., E. F., Philadelphia, Pa.
Kellogg & Co., E. H., New York.
Keystone Lubricating Co., Philadelphia, Pa.
N. Y. & N. J. Lubricant Co., New York.

Grease Extractors
Beggs & Co., James, New York.
Griscom-Spencer Co., New York.
Hussey, McCann & Co., New York.

Heaters and Purifiers, Feed Water
Alberger Condenser Co., New York.
Baragwanath & Son, Wm., Chicago, Ill.
Beggs & Co., James, New York.
Eclipse Feed Water Heater and Purifier Co., Oshkosh, Wis.
Erie Mfg. & Supply Co., Erie, Pa.
Green Fuel Economizer Co., Matteawan, N. Y.
Griscom-Spencer Co., New York.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Mfg. Co., Springfield, O.
Kewanee Boiler Co., Kewanee, Ill.
Loew Mfg. Co., Cleveland, O.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Murray Iron Works Co., Burlington, Iowa.
National Pipe Bending Co., New Haven, Conn.
Patterson & Co., Frank L., New York.
Phoenix Iron Wks. Co., Meadville, Pa.
Robertson & Sons, Jas. L., New York,
Stewart Heater Co., Buffalo, N. Y.
Tudor Boiler Mfg. Co., Cincinnati, O.
Webster & Co., Warren, Camden, N. J.
Wheeler Condenser & Engineering Co., New York.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.
Wickes Bros., Saginaw, Mich.

Heating and Ventilating Systems
Buffalo Forge Co., Buffalo, N. Y.
Green Fuel Economizer Co., Matteawan, N. Y.
Ohio Blower Co., Cleveland, O.
Schutte & Koerting Co., Philadelphia, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Webster & Co., Warren, Camden, N. J.
Wing Mfg. Co., L. J., New York.

Hose
Anchor Packing Co., Philadelphia, Pa.
Bowers Rubber Works, San Francisco, Cal.
Diamond Rubber Co., Akron, Ohio.

Hose—*Continued.*
Garlock Packing Co., Palmyra, N. Y.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Lagonda Mfg. Co., Springfield, O.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
Myers & Bro., F. E., Ashland, O.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Rhoads & Sons, J. E., Phila., Pa.

Indicators, Ammonia
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Indicators, Gas Engine
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Indicators, Speed
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Starrett Co., L. S., Athol, Mass.

Indicators, Steam Engine
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Lippincott Steam Specialty & Supply Co., Newark, N. J.
Robertson & Sons, Jas. L., New York.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Star Brass Mfg. Co., Boston, Mass.
Trill Indicator Co., Corry, Pa.

Injectors
American Injector Co., Detroit, Mich.
Detroit Lubricator Co., Detroit, Mich.
Lunkenheimer Co., Cincinnati, O.
Ohio Injector Co., Wadsworth, O.
Penberthy Injector Co., Detroit, Mich.
Randle Machinery Co., Cincinnati, Ohio.
Robertson & Sons, Jas. L., New York.
Sherwood Mfg. Co., Buffalo, N. Y.

Inspection, Boiler
Fidelity & Casualty Co., New York.
Hartford Steam Boiler Insp. & Ins. Co., Hartford, Conn.

Insurance, Boiler
Fidelity & Casualty Co., New York.
Hartford Steam Boiler Insp. & Ins. Co., Hartford, Conn.

Joints, Expansion
Alberger Condenser Co., New York.
Webster & Co., Warren, Camden, N. J.

Joints, Pipe
Dixon Crucible Co., Jos., Jersey City, N. J.
McCrea & Co., James, Chicago, Ill.

Joints, Rubber
Diamond Rubber Co., Akron, Ohio.

Kiln Equipment
Green Fuel Economizer Co., Matteawan, N. Y.
Ohio Blower Co., Cleveland, O.
Schutte & Koerting Co., Philadelphia, Pa.

Lace, Leather
Rhoads & Sons, J. E., Phila., Pa.
Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.

Lamps, Arc
General Electric Co., Schenectady, N. Y.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Websterizing

A Monthly Bulletin For Steam Engineers

VOL. I. DECEMBER, 1908. No. 6.

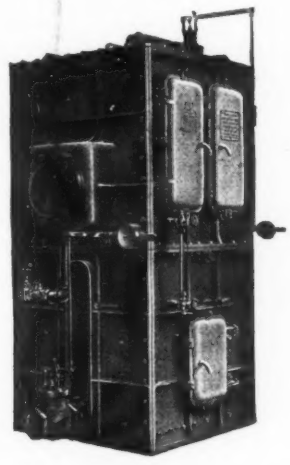
HOT WATER FOR ANY PURPOSE.

How To Get It Most Cheaply.

Laundries, breweries, hotels, hospitals, paper mills, tanneries, dye houses, office buildings, etc., have need of large quantities of clean hot water. For this reason engineers in charge must study and solve the problem of getting the necessary amount in the least expensive way.

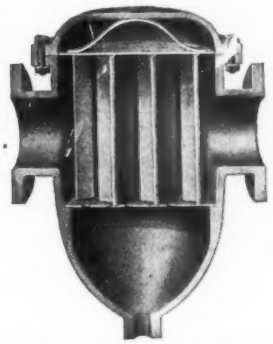
In addition to its regular function of providing the boiler with hot, purified water, the Webster Heater is often installed for the purpose of supplying hot water for various other uses.

The Webster, which uses exhaust steam, heats the water and discharges it into an overhead tank, from which the supply may be drawn as required.



WEBSTER FEED WATER HEATER, PURIFIER AND FILTER.

The exhaust steam is thoroughly purified of its entrained cylinder lubricant by means of the Oil Separator attached to each Webster Heater, and if there is more exhaust than is needed to heat the water, the excess may be used for heating the building in the Webster System of Steam Circulation. If, on the other hand, the exhaust is insufficient, live steam may be admitted through the reducing valve to supplement it—and this amount of live steam will always be at the minimum.



WEBSTER STANDARD HORIZONTAL OIL SEPARATOR.

Thus the engineer may obtain clean hot water in large amounts, usually using only exhaust steam.

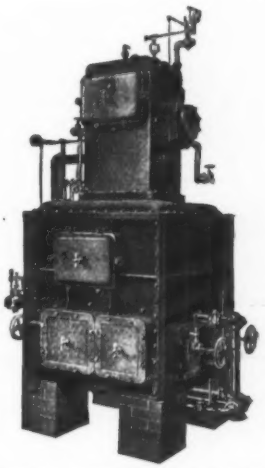
The economy in this plan is obvious.

Besides this use for Webster Heaters there is, of course, the more common one—that of purifying and heating feed water and delivering it to the boilers at the highest possible temperature.

Where the water supply is particularly bad the most effective apparatus known is our Webster Chemical Purifier, which treats the water while it is hot, thus making the work of the chemicals much easier. It is adapted to individual requirements in every case, after a careful analysis of the water, by our expert chemists, and each one is absolutely guaranteed to do the business properly. The use of a Webster Chemical Purifier allows you to locate your plant without reference to the quality of the water supply.

The engineer of every power plant should get acquainted with Webster Steam Specialties. They are a system of devices that make the engine, boiler, coal pile and water supply give the best results, they are capable of. They put a plant on the "continuous maximum efficiency" basis.

We want to send you, free, Heater Booklet, 12-F; Chemical Purifier Booklet, 12-C; and Separator Booklet, 12-S.



WEBSTER CHEMICAL PURIFIER.

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Warren Webster & Co., Camden, N.J.

Lamps, Incandescent

General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Lathes, Foot Power

Barnes Co., W. F. & John, Rockford, Ill.

Lubricants

Carpenter & Co., W. D., New York.
Cook's Sons, Adam, New York.
N. Y. & N. J. Lubricant Co., New York.

Lubricating and Oiling Devices

Lunkenheimer Co., Cincinnati, O.
Nugent & Co., W. W., Chicago, Ill.
Williams Valve Co., D. T., Cincinnati, Ohio.

Lubricators

Chesterton & Co., A. W., Boston, Mass.
Cook's Sons, Adam, New York.
Detroit Lubricator Co, Detroit, Mich.
Greene, Tweed & Co., New York.
Griscom-Spencer Co., New York
Lunkenheimer Co., Cincinnati, O
Manzel Bros. Co., Buffalo, N. Y.
Michigan Lubricator Co., Detroit, Mich.
Ohio Injector Co., Wadsworth, O
Robertson & Sons, Jas. L., New York.
Sherwood Mfg. Co., Buffalo, N. Y
Sight Feed Oil Pump Co., Milwaukee, Wis.
Stephenson Mfg. Co., Albany, N. Y.
Sterling Lubricator Co., Rochester, N. Y.

Machinery, Cement

Power & Mining Machinery Co., Cudahy, Wis

Machinery, Coal and Ash Handling

Bartlett & Snow Co, Cleveland, Ohio.
Jeffrey Mfg Co, Columbus, O

Machinery, Conveying

Bartlett & Snow Co., Cleveland, Ohio.

Machinery, Mining

Wisconsin Engine Co., Corliss, Wis.

Machinery, Refrigerating

De La Vergne Machine Co., New York
Vilter Mfg. Co., Milwaukee, Wis.
Vogt Machine Co., Henry, Louisville, Ky.
York Mfg. Co., York, Pa.

Machinery, Second Hand

Hewes & Phillips Iron Works, Newark, N. J.
Randle Machinery Co., Cincinnati, Ohio.
Wickes Bros., Saginaw, Mich.

Machinery, Smelting and Mining

Moore & Co., Chas C., San Francisco, Cal.

Machines, Blue Print

Buckeye Engine Co., Salem, O.

Machines, Crank Pin Turning

Underwood & Co., H B., Philadelphia, Pa

Machines, Ice

Vilter Mfg. Co., Milwaukee, Wis.

Machines, Milling, Portable

Underwood & Co, H B., Philadelphia, Pa.

Machines, Pipe Cutting and Threading

Armstrong Mfg. Co., Bridgeport, Conn
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Crane Co, Chicago Ill.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Toledo Pipe Threading Machine Co., Toledo, Ohio
Trimont Mfg. Co., Roxbury, Mass.

Machines, Reseating, Flue Cap

Lagonda Mfg. Co., Springfield, O.
Leavitt Machine Co., Orange, Mass.
Liberty Mfg. Co., Pittsburg, Pa.

Machines, Reseating, Valve

Leavitt Machine Co., Orange, Mass.

Machines, Valve Seat Planing

Underwood & Co., H. B., Philadelphia, Pa.

Machinists, General

American & British Mfg. Co., Providence, R. I.
Bruce-Meriam-Abbott Co., Cleveland, O.
Mathews, Hugh, Kansas City, Mo.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Providence Engineering Works, Providence, R. I.

Mats and Matting

Diamond Rubber Co., Akron, Ohio.
Home Rubber Co., Trenton, N. J.
Mercer Rubber Co., Hamilton Square, N. J.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.

Metal, Anti-friction

Allan & Son, A., New York.
Reeves Pulley Co., Columbus, Ind.

Metal, Babbitt

Reeves Pulley Co., Columbus, Ind.

Metal, Bearing

Allan & Son, A., New York.
Reeves Pulley Co., Columbus, Ind.

Metal, Metallic Gasket

Reeves Pulley Co., Columbus, Ind.

Meters, Steam

St. John, G. C., New York.

Micrometers

Starrett Co., L. S., Athol, Mass.

Motors, Electric

American Engine Co., Bound Brook, N. J.
C & C Electric Co., New York.
Clark Bros. Co., Belmont, N. Y.
General Elec. Co., Schenectady, N.Y.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Sturtevant Co., B F., Hyde Park, Mass.
Triumph Elec. Co., Cincinnati, Ohio.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.
Wickes Bros., Saginaw, Mich.

Motors, Water

Lagonda Mfg. Co., Springfield, O.

Nipples

National Tube Co., Pittsburg, Pa.

Oil and Grease Cups

American Injector Co., Detroit, Mich.
Cook's Sons, Adam, New York.
Griscom-Spencer Co., New York.
Keystone Lubricating Co., Philadelphia, Pa.
Liberty Mfg. Co., Pittsburg, Pa.
Lunkenheimer Co., Cincinnati, O.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Sherwood Mfg. Co., Buffalo, N. Y.
Standard Gauge Mfg Co Foxboro, Mass

Oil Burners

Hammel Oil Burner Co., Los Angeles Cal.

Oil Dash Pots

Lammert & Mann, Chicago, Ill.

Oil Reservoirs

Burt Mfg. Co, Akron, O.

Oilers, Crank Pin

Penberthy Injector Co., Detroit, Mich.

Oiling Systems

Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Standard Gauge Mfg. Co., Foxboro, Mass.

Oils

Cook's Sons, Adam, New York.
Dearborn Drug & Chemical Wks., Chicago, Ill.
Harris Oil Co., A. W., Providence, R. I.
Houghton & Co., E. F., Philadelphia, Pa.
Kellogg & Co., E. H., New York.
New York & New Jersey Lubricant Co., New York.

Oils, Non-fluid

N. Y. & N. J. Lubricant Co., New York.

Packing, Asbestos

Johns-Manville Co., H. W., New York.
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
Restein Co., Clement, Philadelphia, Pa.

Packing, Flange

Carey Co., Philip, Cincinnati, O.
Chesterton Co., A. W., Boston, Mass.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Home Rubber Co., Trenton, N. J.
Houghton & Co., E. F, Philadelphia, Pa.
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co, Hamilton Square, N. J.
National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Rhoads & Sons, J. E., Phila., Pa.
Robertson & Sons, Jas. L., New York.
Smooth-On Mfg. Co., Jersey City, N. J.
Walch & Wyeth, Chicago, Ill.

Packing, Hydraulic

Brandt, Randolph, New York.
Chesterton Co., A. W., Boston, Mass.
Detroit Leather Specialty Co., Detroit, Mich.
Diamond Rubber Co., Akron, Ohio
Garlock Packing Co., Palmyra, N. Y.
Home Rubber Co., Trenton, N. J.
Houghton & Co., E F, Philadelphia, Pa.
Johnson Co., Henry, Jersey City, N J
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Robertson & Sons, Jas. L., New York.
Schieren Co., Chas. A., New York.
Steel Mill Packing Co., Detroit, Mich.
Stevens & Co., Chas. L., Detroit, Mich.

Packing, Metallic

American Huhn Metallic Packing Co., New York.
Garlock Packing Co., Palmyra, N. Y.
Houchin-Aiken Co., Brooklyn, N.Y.
Johnson Co., Henry, Jersey City, N. J.
Mercer Rubber Co., Hamilton Square, N. J.
Steel Mill Packing Co, Detroit, Mich.

Packing, Piston

American Steam Packing Co., Boston, Mass.
Bowers Rubber Works, San Francisco, Cal.
Carey Co., Philip, Cincinnati, O.
Chesterton Co., A. W., Boston, Mass.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N J.

Packing, Piston—*Continued.*

National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co. New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Robertson & Sons, Jas. L., New York.
Steel Mill Packing Co., Detroit, Mich.
Underwood & Co., H. B., Philadelphia, Pa.

Packing, Pneumatic

Detroit Leather Specialty Co., Detroit, Mich.
Houghton & Co., E. F., Philadelphia, Pa.
Mercer Rubber Co., Hamilton Square, N. J.
Stevens & Co. Chas. L., Detroit, Mich.

Packing, Pump Valve

Diamond Rubber Co., Akron, Ohio.
Home Rubber Co., Trenton, N. J.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.

Packing, Rod

American Huhn Metallic Packing Co., New York.
Bowers Rubber Co., San Francisco, Cal.
Brandt, Randolph, New York.
Carey Co., Philip, Cincinnati, O.
Chesterton Co., A. W., Boston, Mass.
Diamond Rubber Co., Akron, Ohio.
Flower Steam Specialty Co., Walter L., St. Louis, Mo.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Home Rubber Co., Trenton, N. J.
Johnson Co., Henry, Jersey City, N. J.
Mechanical Rubber Co., Cleveland, O.
Mercer Rubber Co., Hamilton Square, N. J.
National India Rubber Co., Bristol, R. I.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Robertson & Sons, Jas. L., New York.
Steel Mill Packing Co., Detroit, Mich.

Packing, Valve Stem

Diamond Rubber Co., Akron, Ohio.
Home Rubber Co., Trenton, N. J.
Mechanical Rubber Co., Cleveland, Ohio.
Mercer Rubber Co., Hamilton Square, N. J.
Quaker City Rubber Co., Philadelphia, Pa.

Pipe

Ball & Wood Co., Elizabethport, N. J.
See also Tubing.

Pipe, Riveted Steel

Minneapolis Steel & Mchy. Co., Minneapolis, Minn.

Pipe, Wrought

National Tube Co., Pittsburg, Pa.

Pipe Coils

Fairbanks Co., New York.
McCrea & Co., James, Chicago, Ill.
National Pipe Bending Co., New Haven, Conn.
Whitlock Coil Pipe Co., Hartford, Conn.

Pipe Hangers

Fairbanks Co., New York.

Piping, Blow

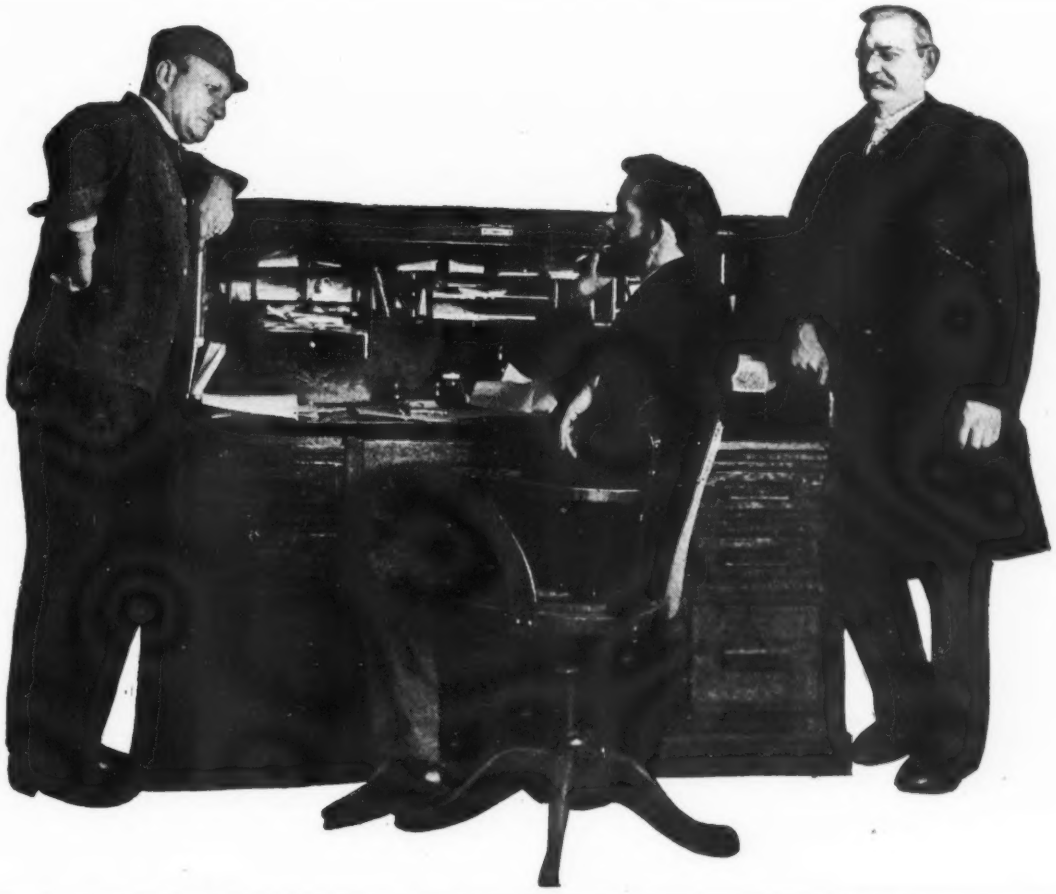
Ohio Blower Co., Cleveland, O.

Planimeters

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Lippincott Steam Specialty & Supply Co., Newark, N. J.
Robertson & Sons, Jas. L., New York.

Plumbago

Dixon Crucible Co., Jos., Jersey City, N. J.



Don't take Mac's word for it

ASK YOUR ENGINEER

if he doesn't think your boiler feed water ought to be analyzed—we'll abide by his decision. He is interested in your welfare, and his own, not ours. Even if you have no scale, there is danger of pitting and corrosion, with a possible explosion liable to occur any moment.

A case of this kind in New England recently came to our notice: The engineer frequently warned the owner about the pitting and corrosion that was going on, but he only smiled, until the explosion blew the engineer and thirty other employees into eternity, then—why of course he was sorry, but that did not pay his liabilities.

We offer to analyze your feed water or boiler scale

FREE OF CHARGE

If the water needs no treatment, we will tell you so frankly; if it does, we will prescribe a combination of

LORDS WATER PURIFYING CHEMICALS

which we will guarantee to remedy whatever trouble exists, but which you are in no way obligated to purchase.

We will take the risk of being able to demonstrate to your satisfaction that it will pay you to use it.

We have no ready-made boiler compounds. We treat water after analysis only—that is why we never fail.

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Hoffman, Geo. W., Indianapolis, Ind.

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Audel & Co., New York
Hill Publishing Co., New York.
International Correspondence Schools, Scranton, Pa.
System Co., Chicago, Ill.

Pulleys

American Pulley Co., Phila., Pa.
Fairbanks Co., New York.
Houghton & Co., E. F., Philadelphia, Pa.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Philips Pressed Steel Pulley Works, Philadelphia, Pa.
Reeves Pulley Co., Columbus, Ind.

Pulleys, Clutch

Williams Foundry & Mach. Co., Akron, Ohio.

Pumps, Air

American Steam Pump Co., Battle Creek, Mich.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
Du Bois Iron Works, Du Bois, Pa.
Goulds Mfg. Co., Seneca Falls, N. Y.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Prescott Steam Pump Co., F. M., Milwaukee, Wis.
Warren Steam Pump Co., Warren, Mass.
Wheeler Condenser & Engineering Co., New York.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Pumps, Boiler Feed

American Steam Pump Co., Battle Creek, Mich.
Kewanee Boiler Co., Kewanee, Ill.
Warren Steam Pump Co., Warren, Mass.

Pumps, Centrifugal

Alberger Condenser Co., New York.
Morris Machine Works, Baldwinsville, N. Y.
Wheeler Condenser & Engineering Co., New York.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Pumps, Compound

Warren Steam Pump Co., Warren, Mass.

Pumps, Deep Well

Warren Steam Pump Co., Warren, Mass.

Pumps, Electric

Dean Bros. Steam Pump Works, Indianapolis, Ind.
Du Bois Iron Works, Du Bois, Pa.
Goulds Mfg. Co., Seneca Falls, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Pumps, Hydraulic

American Steam Pump Co., Battle Creek, Mich.
Goulds Mfg. Co., Seneca Falls, N. Y.
Union Steam Pump Co., Battle Creek, Mich.
Warren Steam Pump Co., Warren, Mass.

Pumps, Oil

American Steam Pump Co., Battle Creek, Mich.
Burt Mfg. Co., Akron, O.
Detroit Lubricator Co., Detroit, Mich.
Du Bois Iron Works, Du Bois, Pa.
Goulds Mfg. Co., Seneca Falls, N. Y
Lunkenheimer Co., Cincinnati, O.
Manzel Bros. Co., Buffalo, N. Y.
Sherwood Mfg. Co., Buffalo, N. Y.
Sight Feed Oil Pump Co., Milwaukee, Wis.
Union Steam Pump Co., Battle Creek, Mich.

Pumps, Oil, Force-Feed

Sterling Lubricator Co., Rochester, N. Y.

Pumps, Power

Deming Co., Salem, Ohio.
Myers & Bro., F. E., Ashland, O.
Patterson & Co., Frank L., New York.
Stewart Heater Co., Buffalo, N. Y
Union Steam Pump Co., Battle Creek, Mich.
Whitlock Coil Pipe Co., Hartford, Conn.

Pumps, Steam

American Steam Pump Co., Battle Creek, Mich.
Buffalo Steam Pump Co., Buffalo, N. Y.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
Du Bois Iron Works, Du Bois, Pa.
Epping-Carpenter Co., Pittsburg, Pa.
Gardner Governor and Separator Co., Quincy, Ill.
Mason Regulator Co., Boston, Mass.
Minneapolis Steel & Machy. Co., Minneapolis, Minn.
Murray Iron Works Co., Burlington, Iowa.
Prescott Steam Pump Co., F. M., Milwaukee, Wis.
Union Steam Pump Co., Battle Creek, Mich.
Wheeler Condenser & Engineering Co., New York.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Pumps, Triplex

Minneapolis Steel & Mchry. Co., Minneapolis, Minn.

Pumps, Turbine

Alberger Condenser Co, New York.

Pumps, Vacuum

Alberger Condenser Co., New York.
American Steam Pump Co., Battle Creek, Mich.
Prescott Steam Pump Co., F. M., Milwaukee, Wis.
Schutte & Koerting Co., Philadelphia, Pa.
Union Steam Pump Co., Battle Creek, Mich.
Warren Steam Pump Co., Warren, Mass.
Wheeler Condenser & Engineering Co., New York.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Purifiers, Feed Water

Keyes & Son, F. E., New York.
See also Heaters and Purifiers

Rams, Steam

Penberthy Injector Co., Detroit, Mich.

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Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Reducing Wheels

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Robertson & Sons, Jas. L., New York.
Trill Indicator Co., Corry, Pa.

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Davis Regulator Co. G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Lagonda Mfg. Co., Springfield, O.
Mason Regulator Co, Boston, Mass.
Robertson & Sons, Jas. L., New York.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Strong, Carlisle & Hammond Co., Cleveland, O.

Regulators, Feed Water

American Boiler Economy Co., Philadelphia, Pa.
Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Pittsburg, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Jerguson Mfg. Co., Boston, Mass.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
Mason Regulator Co., Boston, Mass.
Murray Automatic Boiler Feed Co., Detroit, Mich.

Regulators, Feed Water —*Continued.*

Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Philadelphia, Pa.

Regulators, Pressure

American Boiler Economy Co., Philadelphia, Pa.
American District Steam Co., Lockport, N. Y.
Davis Regulator Co., G. M., Chicago, Ill.
Fisher Governor Co., Marshalltown, Iowa.
Golden-Anderson Valve Specialty Co., Pittsburg, Pa.
Lagonda Mfg. Co., Springfield, O.
Mason Regulator Co., Boston, Mass
Ohio Brass Co., Mansfield, Ohio.
Strong, Carlisle & Hammond Co., Cleveland, O.

Regulators, Rheostat

Mason Regulator Co., Boston, Mass.

Repairs, Engine and Pump

Underwood & Co., H. B., Philadelphia, Pa.

Revolution Counters

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Schuchardt & Schutte, New York.

Rope, Transmission

American Mfg. Co., New York.

Rubber Goods

Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Griscom-Spencer Co., New York.
Home Rubber Co., Trenton, N. J.
Houghton & Co., E. F., Philadelphia, Pa.
Mechanical Rubber Co., Cleveland, Ohio.
Mercer Rubber Co., Hamilton Square, N. J.
National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Rhoads & Sons, J. E., Philadelphia, Pa.

Rust Preventers

Houghton & Co., E. G., Philadelphia, Pa.

Scales, Coal Hopper

Fairbanks Co., New York.

Scales, Wheelbarrow

Fairbanks Co, New York.

Schools, Correspondence

American School of Correspondence, Chicago, Ill.
International Correspondence Schools, Scranton, Pa.

Separators, Ammonia

Harrison Safety Boiler Works, Philadelphia, Pa.

Separators, Oil

Austin Separator Co., Detroit, Mich.
Baragwanath & Son, Wm., Chicago, Ill.
Direct Separator Co., Syracuse, N. Y.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hershey Foundry & Machine Co., Manheim, Pa.
Hoppes Mfg. Co., Springfield, O.
Hussey, McCann & Co., New York.
Liberty Mfg. Co., Pittsburg, Pa.
Loew Mfg. Co., Cleveland, O.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Ohio Blower Co., Cleveland, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Robertson & Sons, Jas. L., New York.
Webster & Co., Warren, Camden, N. J.
Williams Valve Co., D. T., Cincinnati, Ohio.
Wright Mfg. Co., Detroit, Mich.

Separators, Oil and Water

Harrison Safety Boiler Works, Philadelphia, Pa.
Keyes & Son, F. E., New York.

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Baragwanath & Son, Wm., Chicago, Ill.
d'Este & Co., Julian, Boston, Mass.
Direct Separator Co., Syracuse, N. Y.
Gardner Governor and Separator Co., Quincy, Ill.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hershey Foundry & Machine Co., Manheim, Pa.
Hoppes Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
Loew Mfg. Co., Cleveland, O.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Ohio Blower Co., Cleveland, O.
Patterson & Co., Frank L., New York.
Pittsburgh Gage & Supply Co. Pittsburg, Pa.
Robertson & Sons, Jas. L., New York.
Webster & Co., Warren, Camden, N. J.
Whitlock Coil Pipe Co., Hartford, Conn.
Williams Valve Co., D. T., Cincinnati, Ohio.
Wright Mfg. Co., Detroit, Mich.

Shafts, Counter

Myers & Bro., F. E., Ashland, O.

Sheaves

Minneapolis Steel & Mchy. Co., Minneapolis, Minn.

Skimmers, Boiler

Buckeye Boiler Skimmer Co., Toledo, Ohio.

Skylights

Burt Mfg. Co., Akron, O.

Smoke Preventers

Climax Smoke Preventer Co., Boston, Mass.

Specialties, Power Plant

Fairbanks Co., New York.
Ohio Brass Co., Mansfield, Ohio.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Standard Gauge Mfg. Co., Foxboro, Mass.
Williams Valve Co., D. T., Cincinnati, Ohio.

Stacks, Steel

Bigelow Co., New Haven, Conn.
Keeler Co., E., Williamsport, Pa.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Morrin Climax Boiler Co., Brooklyn, N. Y.

Stocks, Die

Armstrong Mfg. Co., Bridgeport, Conn.
Toledo Pipe Threading Machine Co., Toledo, O.

Stokers, Mechanical

Crowe, Paul L., Jersey City, N. J.
Detroit Stoker and Foundry Co., Detroit, Mich.
Green Engineering Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Murphy Iron Works, Detroit, Mich.
Westinghouse Mach. Co., Pittsburg, Pa.
Wilkinson Mfg. Co., Bridgeport, Pa.

Strainers

American Injector Co., Detroit, Mich.
Liberty Mfg. Co., Pittsburg, Pa.
Webster & Co., Warren, Camden, N. J.

Superheaters

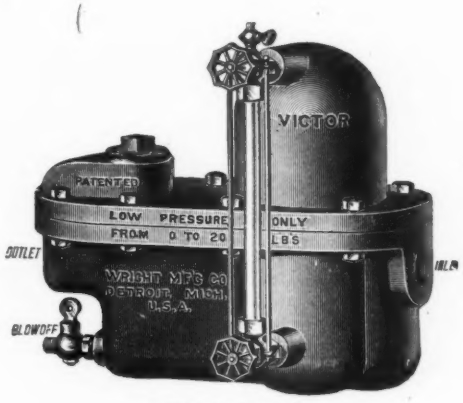
Babcock & Wilcox Co., New York.
Parker Boiler Co., Philadelphia, Pa.
Power Specialty Co., New York.
Providence Engineering Works, Providence, R. I.

Supplies, Mill

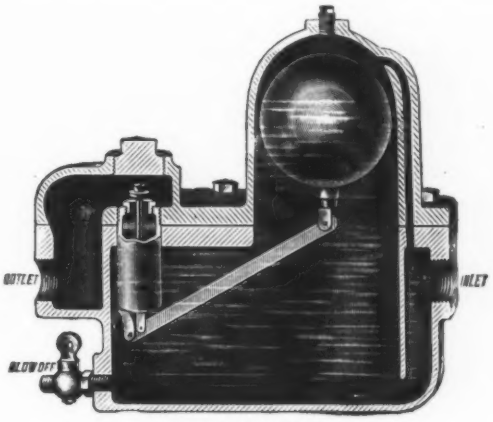
Quaker City Rubber Co., Philadelphia, Pa.

Supplies, Steam Heating

Beggs & Co., James, New York.
Crosby Steam Gage & Valve Co., Boston, Mass.
Dunham Co., C. A. Marshalltown, Iowa.
Eastwood Wire Mfg. Co., Belleville, N. J.
Fisher Governor Co., Marshalltown, Iowa.
New York Belting & Packing Co., New York.
Ohio Brass Co., Mansfield, O.



EXTERIOR VIEW.



SECTIONAL VIEW.

The Wright Victor Low Pressure Steam Trap

For All Low Pressure Steam Systems.

One large valve in this trap drains automatically and continually the accumulating condensation from steam lines regardless of small flows or floods and without the waste of a pound of steam in operation. Operates perfectly whether the steam gauge registers "20 lbs." or "no steam." Shipped on trial at our risk of transportation charges. Send for catalog.

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As fine as on watches to insure perfect gears, pinions and tubes. We make *all* parts ourselves so as to know they are right.

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All working parts held by same mounting. Independent of case and free from "case errors."

MATERIALS

Selected bronze for plates and segments; hard German silver for pinions, so that durability is certain even with hardest service.

WE ARE PROUD OF EVERY PART OF OUR GAUGES, INSIDE AND OUT.

IF YOU NEED ANY SORT OF GAUGE FOR ANY SORT OF WORK, LOOK IN OUR BULLETIN E-2.

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THE STANDARD GAUGE MFG. CO., Foxboro, Mass.

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Strong, Carlisle & Hammond Co., Cleveland, O.
Wright Mfg. Co., Detroit, Mich.

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General Electric Co., Schenectady, N. Y.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Switches, Electric
General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Syphons
National Tube Co., Pittsburg, Pa.

Tachometers
Schuchardt & Schutte, New York.

Tanks
Bigelow Co., New Haven, Conn.
Griscom-Spencer Co., New York.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
New Bedford Boiler & Mach. Co., New Bedford, Mass.
Phoenix Iron Wks. Co., Meadville, Pa.

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Toledo Pipe Threading Machine Co., Toledo, O.

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Bristol Co, Waterbury, Conn.

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Mound Tool & Scraper Co., St. Louis, Mo.
Trimont Mfg. Co., Roxbury, Mass.

Transformers and Converters
General Electric Co., Schenectady, N. Y.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Transmission, Power
American Mfg. Co., New York.
American Pulley Co., Philadelphia, Pa.
Gandy Belting Co., Baltimore, Md.
Jeffrey Mfg. Co., Columbus, O.
Mesta Machine Co., Pittsburg, Pa.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Reeves Pulley Co., Columbus, Ind.
Rhoads & Sons, J. E., Philadelphia, Pa.

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American District Steam Co., Lockport, N. Y.
Anderson Co., V. D., Cleveland, O.
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Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Direct Separator Co., Syracuse, N. Y.
Dunham Co., C. A., Marshalltown, Iowa.
Flinn, Richard J., W. Roxbury Station, Boston, Mass.
Golden-Anderson Valve Specialty Co., Pittsburg, Pa.
Harrison Safety Boiler Works, Philadelphia, Pa.
Houghton & Co., E. F., Philadelphia, Pa.
McCrea & Co., James, Chicago, Ill.
Morehead Mfg. Co., Detroit, Mich.
Ohio Blower Co., Cleveland, O.
Platt & Co., John, New York.
Reliance Gauge Column Co., Cleveland, O.
Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Philadelphia, Pa.
Webster & Co., Warren, Camden, N. J.
Williams Valve Co., D. T., Cincinnati, Ohio.
Wright Mfg. Co., Detroit, Mich.

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Westinghouse Mach. Co., Pittsburg, Pa.

Tube Cutters
Lagonda Mfg. Co., Detroit, Mich.

Tube Protectors, Boiler
Cruise & Co., Elizabeth, N. J.

Tubing
National Tube Co., Pittsburg, Pa.
See also Pipe.

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Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa;

Tubes, Boiler, Welded and Seamless
National Tube Co., Pittsburg, Pa.

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De Laval Steam Turbine Co., Trenton, N. J.
General Elec. Co., Schenectady, N. Y.
Kerr Turbine Co., Wellsville, N. Y.
Westinghouse Machine Co., Pittsburg, Pa.
Wing Mfg. Co., L. J., New York.

Unions
Bard Union Co., Norwich, Conn.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Dart Mfg. Co., E. M., Providence, R. I.
Jefferson Union Co., Lexington, Mass.
National Tube Co., Pittsburg, Pa.
Ohio Brass Co., Mansfield, O.

Valve Balls
Diamond Rubber Co., Akron, Ohio

Valve Discs
Allan & Son, A., New York.
Diamond Rubber Co., Akron, Ohio.
Mechanical Rubber Co., Cleveland, O.

Valves, Ammonia
York Mfg. Co., York, Pa.

Valves, Angle
New Bedford Boiler & Mach. Co., New Bedford, Mass.

Valves, Automatic
Golden-Anderson Valve Specialty Co., Pittsburg, Pa
Lagonda Mfg. Co., Springfield, O.
Webster & Co., Warren, Camden, N. J.

Valves, Automatic Relief
Standard Gauge Mfg. Co., Foxboro, Mass.

Valves, Balance
Mason Regulator Co., Boston, Mass.

Valves, Blow-off
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Fairbanks Co., New York.
Homestead Valve Mfg. Co., Pittsburg, Pa.
Liberty Mfg. Co., Pittsburg, Pa.
Ludlow Valve Mfg. Co., Troy, N. Y.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Valves, Boiler Stop
Davis Regulator Co., G. M., Chicago, Ill.
New Bedford Boiler & Mach. Co., New Bedford, Mass.

Valves, By-pass
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Mason Regulator Co., Boston, Mass.

Valves, Check
Fairbanks Co., New York.
Greene, Tweed & Co., New York.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Ludlow Valve Mfg. Co., Troy, N. Y.
Nelson Valve Co., Philadelphia, Pa.
Pittsburgh Valve and Fittings Co., Barberton, Ohio.

Valves, Cylinder Relief
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.

Valves, Electric
Nelson Valve Co., Philadelphia, Pa.

Valves, Exhaust
Nelson Valve Co., Philadelphia, Pa.

Valves, Exhaust Relief
Alberger Condenser Co., New York.
Davis Co., John, Chicago, Ill.

Valves, Foot
New Bedford Boiler & Mach. Co., New Bedford, Mass.

Valves, Gas
Nelson Valve Co., Philadelphia, Pa.

Valves, Gate
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Fairbanks Co., New York.
Greene, Tweed & Co., New York.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Ludlow Valve Mfg. Co., Troy, N. Y.
Lunkenheimer Co., Cincinnati, Ohio.
Nelson Valve Co., Philadelphia, Pa.
Ohio Brass Co., Mansfield, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Pittsburgh Valve & Fittings Co., Barberton, Ohio.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburg, Pa.
Schutte & Koerting Co., Philadelphia, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Globe
Detroit Lubricator Co., Detroit, Mich.
Eastwood Wire Mfg. Co., Belleville, N. J.
Fairbanks Co., New York.
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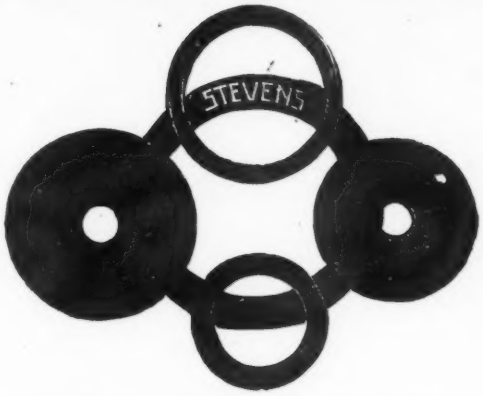

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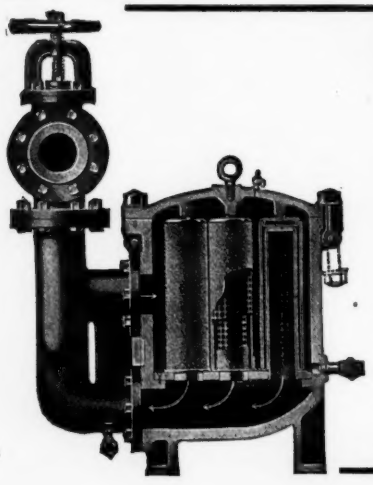

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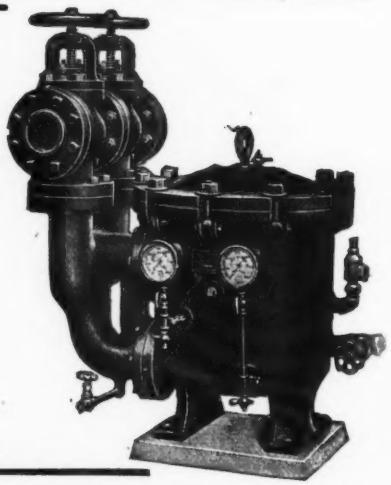

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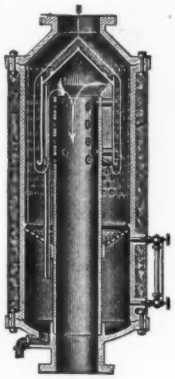

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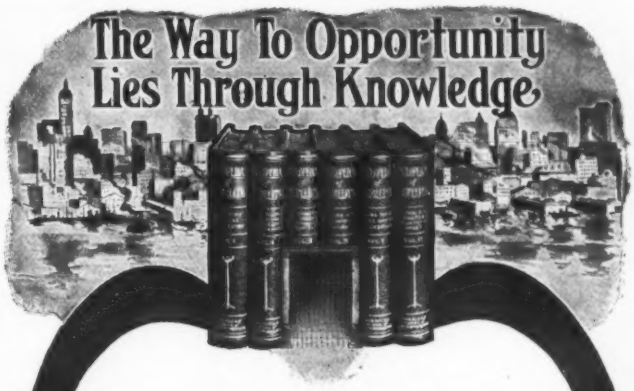

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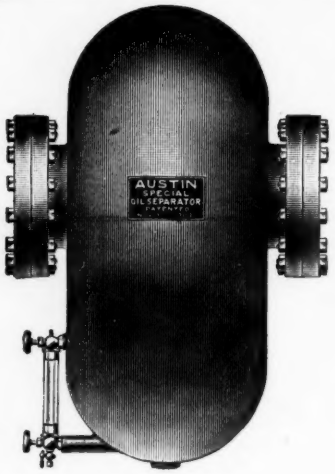

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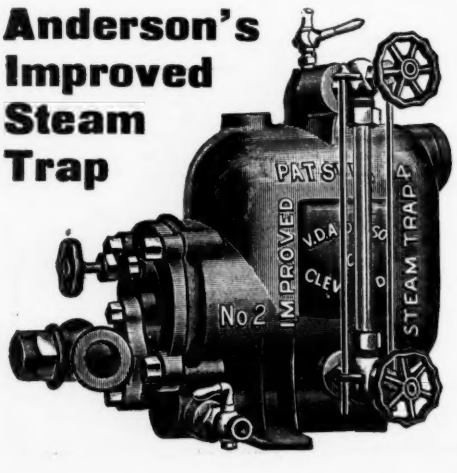

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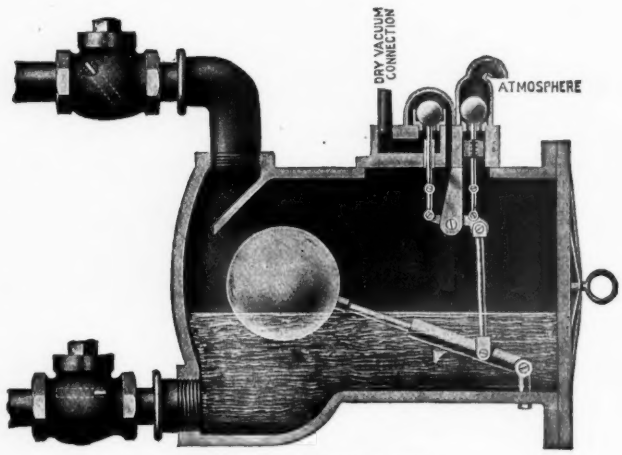

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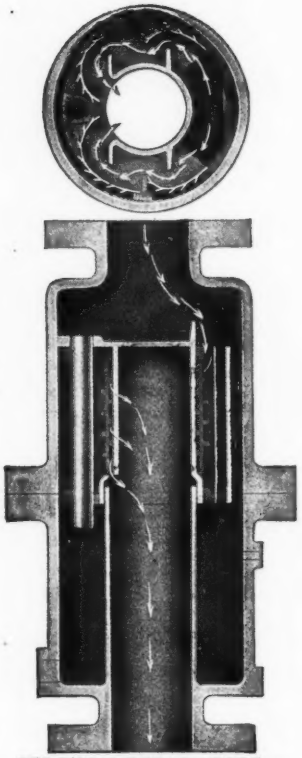

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The STRONG, CARLISLE & HAMMOND CO.

342 Frankfort Ave., CLEVELAND, OHIO.

88 Broad St., BOSTON.

54 No. 6th St., PHILADELPHIA.

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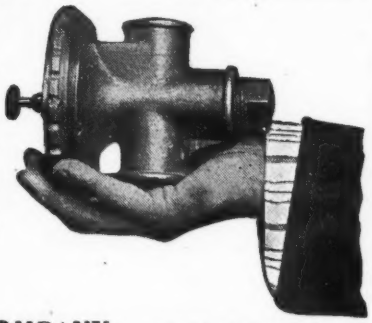
Morehead Steam Traps Operate By Gravity

and have no valves, floats, buckets or inside mechanism of any kind to get out of order and cause trouble. They are the simplest, most efficient devices known for draining condensation from steam systems. Details?

Morehead Manufacturing Co.,
1051 Grand River Ave., DETROIT, MICH.

The "DUNHAM" Is the Smallest In the World



yet it has the largest capacity of any steam trap on the market. It operates by the power of an expanding volatile fluid and is perfectly reliable at any pressure.

CATALOG?

C. A. DUNHAM COMPANY, Marshalltown, Iowa.
Cleveland Philadelphia Chicago Toronto

NO ESCAPE

of steam is possible where **GEIPEL STEAM TRAPS** are in use. Let us send you one on trial.

JOHN PLATT & COMPANY,
97 Cedar St., New York.

"Hard Lines"
The Trudge for Work.

He's certainly to be pitied—the *untrained* man without a job. Just one of the hopeless, struggling crowd.

Every *good* position—requiring special knowledge—is closed against him.

And there's always a line of *others* "waiting to see the foreman" or rushing to answer the advertisement, for the poorest bread-and-butter job.

Just your two hands and your shop experience wouldn't carry *you* far—if slack times should come.

Let your dread for the future stimulate you to do something *now* to improve your chances. Set your mind on the better position you want—and win it.

Don't waste your time "thinking it over"—don't build air castles, just buckle down and do it.

Why not make the start today that will keep you forever out of the hand-to-mouth class? Put in part of the long Winter evenings at home, fitting yourself for a better *kind* of work, and bigger pay.

We can help you. There's always a big demand for men *trained* in engineering work—Steam, Electrical, Mechanical, Civil or Architectural. Get a thorough technical training that will fit you to hold one of these well paid positions—through our simple, practical courses of Home Study. And without loss of time in your present work.

Let the American School of Correspondence tell you how to get more pay now and insure yourself a good position all your life. We employ no agents. Like all strictly educational institutions we depend upon our usefulness for our growth.

Ask for our advice and the proof of what we have done for 80,000 others. Mark and send coupon—today. We'll send you a valuable book FREE describing our complete courses.

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....Locomotive Engineer	....Sheet Metal Pattern Draftsman
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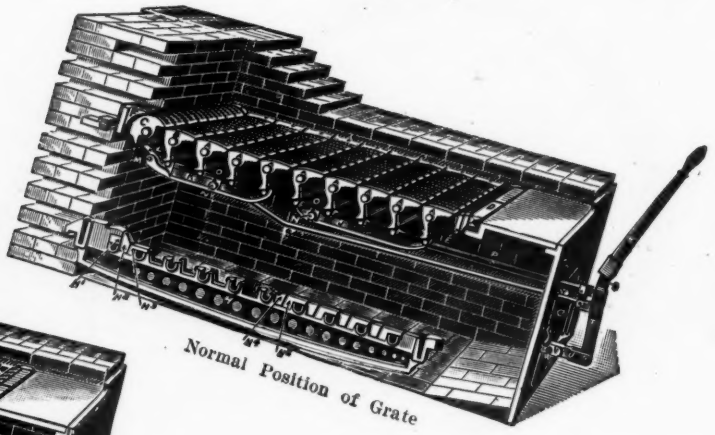
....Structural Draftsman	
....Telephone Engineer	....Sanitary Engineer

Name.....

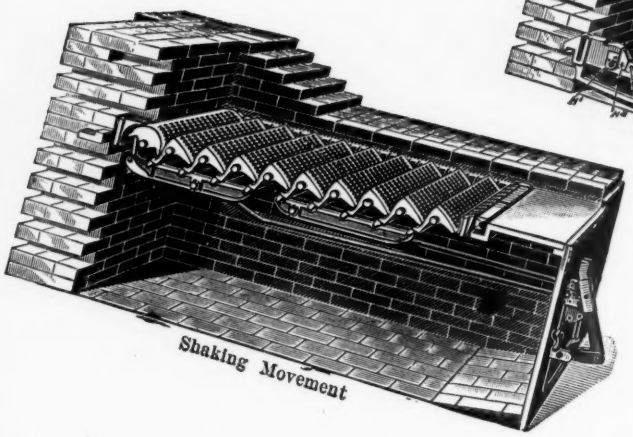
Address.....

Occupation.....

Power, 12-1-08.



Normal Position of Grate



Shaking Movement

Why Should You Support The Coal Man?

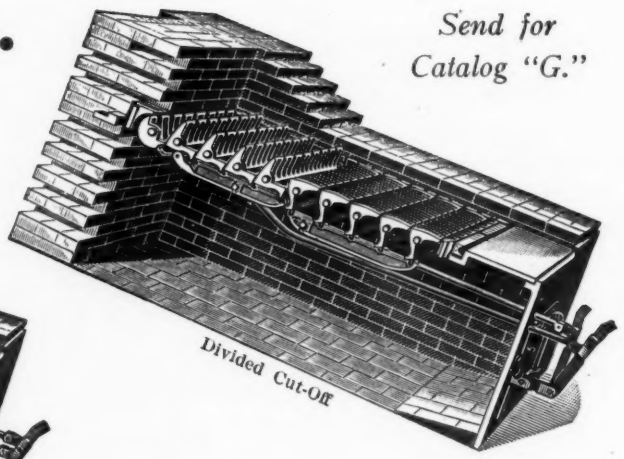
You shouldn't—and you needn't if you'll install McClave Grates with Argand Blowers. They make a combustive combination that gets as good results from anthracite birdseye, bituminous slack, screenings, duff, etc., as other grates obtain using high priced coal. The fire can always be cleaned quickly and easily without opening doors and perfect combustion is insured at all times, with any fuel.

Argand Steam Blower

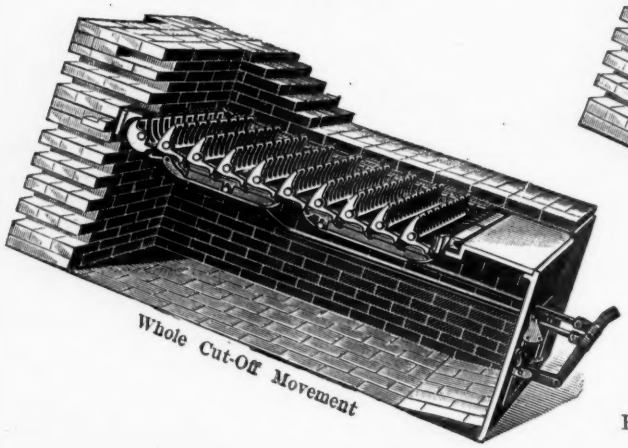
McClave-Brooks Co.

Scranton, Pa.

Send for Catalog "G."



Divided Cut-Off



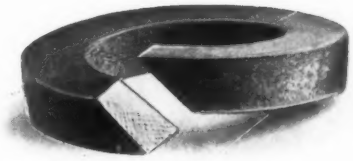
Whole Cut-Off Movement

BRANCH OFFICES: Charles N. Hays, Sales Agent, Fisher Building, Chicago; Empire Building, Pittsburg.

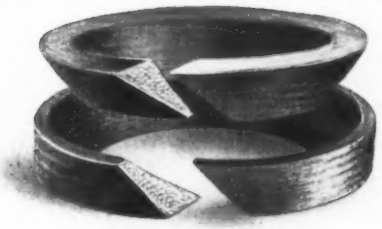
PEERLESS PISTON AND VALVE ROD PACKING

We make the Peerless Piston and Valve Rod Packing round and square. It is put up in coil, spiral and ring form.

Will hold FOUR HUNDRED POUNDS of Steam



Style 1



Style 2

In Sizes from One-eighth Inch to Two & One-Half Inches

Style 3

Style 4

YOU CAN GET FROM 12 TO 18 MONTHS' PERFECT SERVICE FROM PEERLESS PACKING

For high or low pressure steam the Peerless is Head and SHOULDERS above all other packings.

Manufactured Exclusively by

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Boston, Mass.—110 Federal Street.
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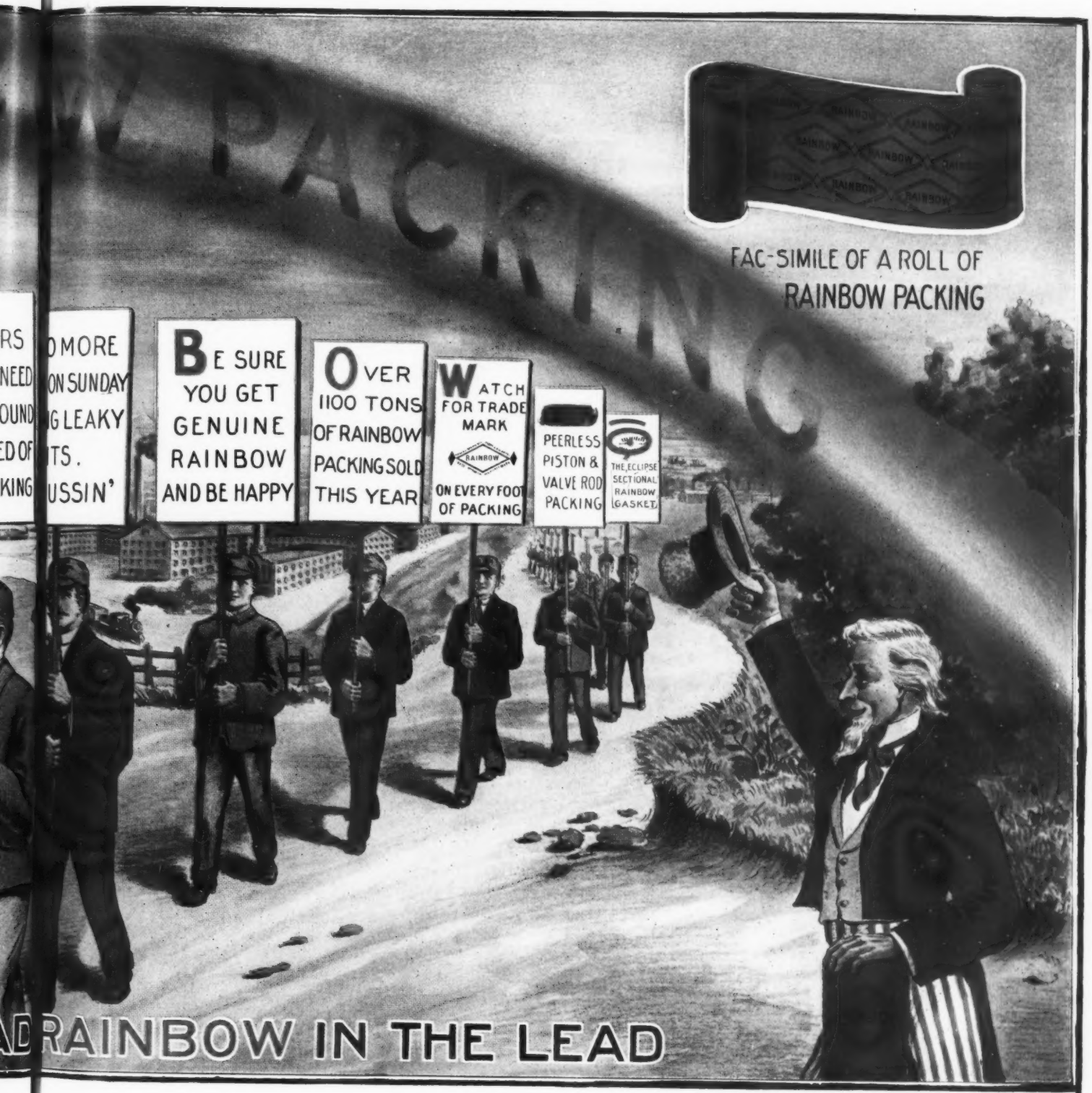
MANUFACTUR

THE PEERLESS RUBBE

16 WARREN STE



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EET, NEW YORK

THE ECLIPSE SECTIONAL RAINBOW GASKET

The original and only genuine Sectional Gasket—manufactured from the celebrated Rainbow Packing Compound. Beware of cheap tubings and worthless imitations. Be sure the name Eclipse is embedded in the gasket at intervals of six inches.

RAINBOW

PUMP VALVE
For Cold Water.

We give Special Attention to the Manufacture of Valves and guarantee them to meet any requirement.

ACME

PUMP VALVE
For Hot Water.

Our experience in the manufacture of Pump Valves enables us to produce valves best suited to the various uses. They are specially prepared to withstand the action of steam, hot and cold water, salt water or oil. We make Special Valves for every purpose.

Also manufacturers of Braided Flax, Tucks Round, Standard Piston, Canvas Rubber Back, and Special Canvas Pump Packings, etc.

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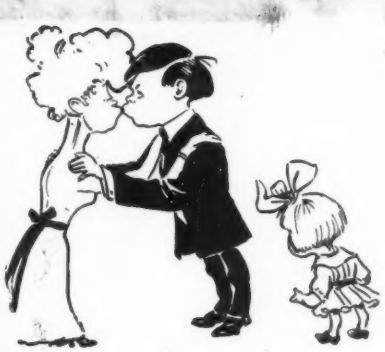

Eureka Gum Core in water end of pump—any pressure —gives great satisfaction.

"A little knowledge is a dangerous thing."

An engineer may know about just a few of the good points of *Genuine* EUREKA PACKING—but not enough to try it. In that case his lack of knowledge is causing a waste of time and money—that Eureka would save.

Here are a few of its "points": Eureka is made of a pure rubber core, pure flax is braided over it, pure lubricant is used inside and out; it gives perfect satisfaction on worn or scored rods; it does not wear the rod; it is the nearest frictionless of any packing; it prevents loss of power; it requires less repacking; it costs one-third less.

Now will you give Eureka a trial?

We also make Cut Ring, High Pressure, Water Proof Hydraulic, in coils and rings, Spiral and Red Sheet Packings.

Write for Samples and Prices.

EUREKA PACKING CO.

JAS. L. ROBERTSON, President

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Be a leader, not a follower. Own an indicator and be *sure* your engine is developing all the power it should for the fuel consumed. Buy the best at first—the Robertson-Thompson—and you'll have no more trouble. We sell it together with the Victor Reducing Wheel, at a moderate price, on easy terms if desired. Write at once for particulars.

The Willis Planimeter is the finest instrument made. The price is within reach of all.

JAS. L. ROBERTSON & SONS

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Cobb's High Pressure Spiral Piston Rod and Valve Stem Packing

Cobb's Throttle Packing

Cobb's High Pressure Ring Packing

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THESE illustrations show a few of our standard, high grade, Spiral, Ring and Sheet Packings, which we manufacture for use in Locomotives, Steamships, Paper Mills, Saw Mills, Mines and Mill Engines of all kinds.

We have doubled the capacity of our Packing Department, at the Factory and are equipped to make Packings to meet any condition at short notice. Write for samples and Engineers' Catalogue, showing our full line.

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Indestructible White Sheet Packing

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HOME RUBBER CO. TRENTON, N. J.
STEAM
NEVER BURN BLOW OUT.
PACKING.
CHICAGO TRADE MARK NEW YORK

N. B. O.

Original Black Sheet Packing

is the old reliable kind that can never burn, blow, rot or squeeze out. It's made of the very finest materials in the most careful manner and under strenuous, severe service it always gives perfect satisfaction.

O. I. M.
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Low Pressure
Use where pressure does not exceed 100 lbs.

O. I. M. has the same high quality as N. B. O. It is made with two diagonal wedges which slip on each other and automatically adjust themselves to all surface variations. It has no equal for scored or uneven rods and has proved itself a big saver of time, money and trouble in hundreds of plants.

O. I. M.
on its merit

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Use where pressure is above 100 lbs.

If your dealer hasn't it—write us direct.

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80 and 82 Reade St.

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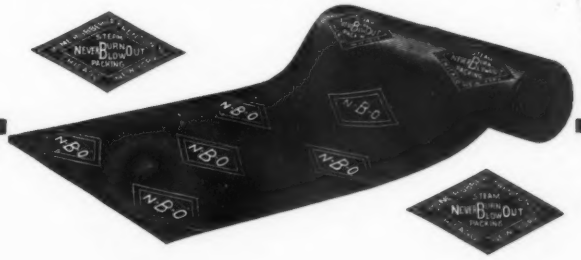

FREE OF ALL CHARGE

Any engineer can obtain free of all charge a set of finely made and handy packing tools. We will present them to you when you have purchased Fifty Dollars Worth of RED BREAST, OR SAYEN-REED PACKING.

ENGINEER'S PACKING TOOLS

They are made from the best selected special tool steel, and are tempered by a special process which makes them very hard while preserving their original toughness.

They will not break or bend in use, and are a great convenience to any engineer.

Full nickle plated, and highly polished.

Every engineer should have a set.

We make this special offer to interest you in our packings, knowing that if you once test them you will continue to use them.

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MERCER RUBBER COMPANY,

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ENGINEERS WHO HAVE USED

INDIAN RED SHEET PACKING

Will tell you it has the

STAYING AND RESISTING QUALITIES

It is efficient in every respect which, in the end, means economy.

A 14 x 28 hanger, like cut herewith, but in colors, free to any engineer upon request.

The DIAMOND RUBBER CO., AKRON, OHIO.

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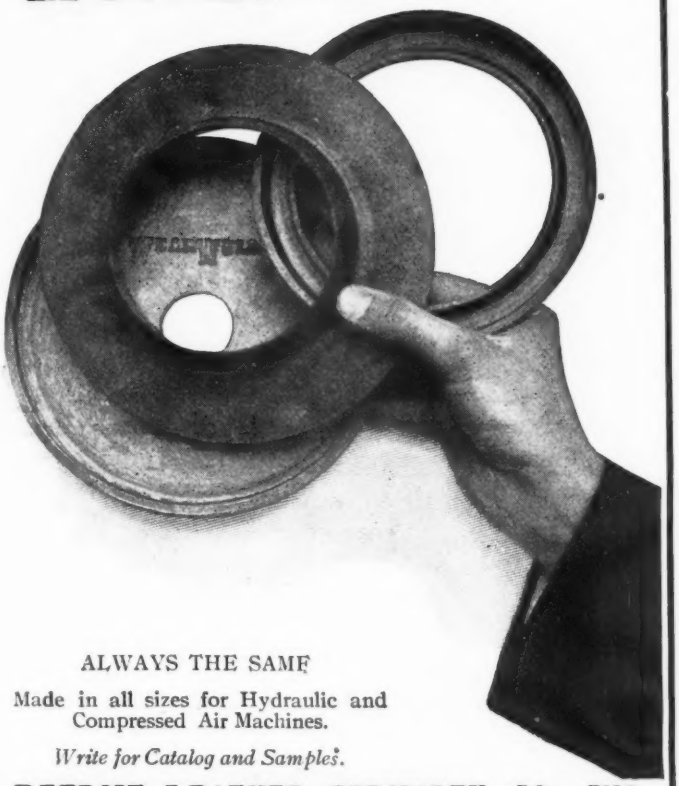
WEARWELL LEATHER PACKINGS



ALWAYS THE SAME

Made in all sizes for Hydraulic and Compressed Air Machines.

Write for Catalog and Samples.

DETROIT LEATHER SPECIALTY CO., INC.,

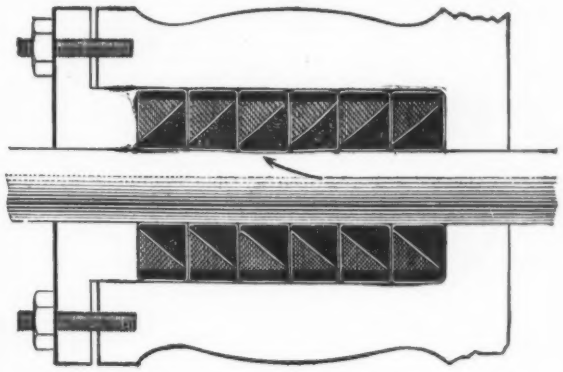
175 Beecher Avenue, Detroit, Mich.

The Simplest of all Sectional Packings is

COMBINATION

(Trade Mark Registered)

Steam and Hydraulic Packing



It has the advantages of any of the old style sectional packings—and many of its own. **Soft Flax only** forms the wearing surface, while the back of **Pure Rubber** gives it **elasticity.** The **expansion** of rubber **alone** will **keep** it **tight.**

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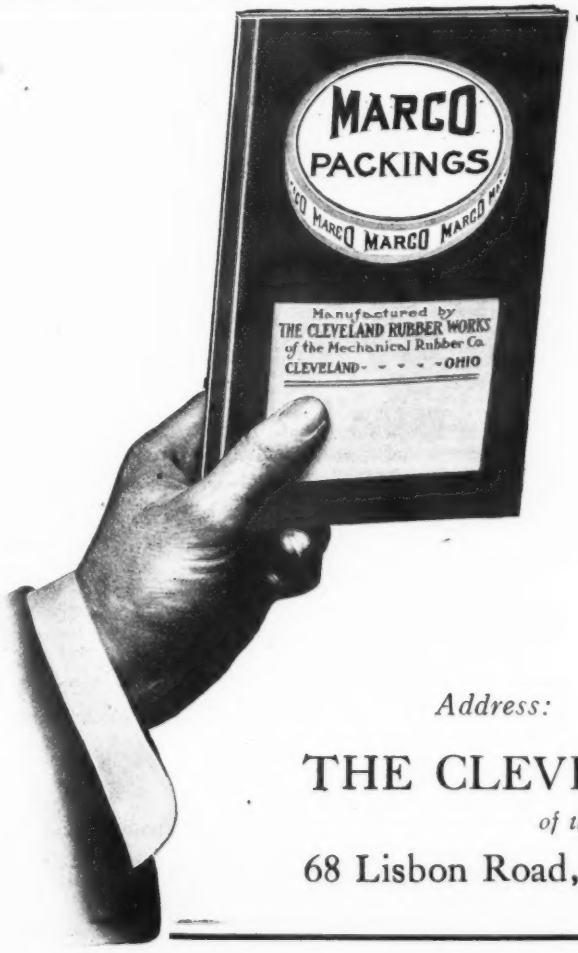
Or Advance Packing and Supply Co., 123 Franklin St., Chicago.



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TRADE MARK MARCO REG. IN U.S. PAT. OFF.

Packing Catalogue

for

1909

Is now ready for distribution

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of the MECHANICAL RUBBER CO.

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The Hydraulic Packing

For High Pressures

BRISTOL

Packings are permanently efficient in places where the service is extremely severe. They easily outlast others and save a large part of the "packing appropriation."

Write us for details and prices.

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Bristol, - R. I.

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"SAFETY" PLASTIC METALLIC PACKING

For Steam, Water, Air, Gas, Hydraulic Machines, Valves, Etc.

Guaranteed to stand Steam Temperature up to 550° F. and Hydraulic Pressure to 5000 lbs. per sq. inch.

Highest Award World's Fair, St. Louis.

Send for **FREE SAMPLE** and particulars.

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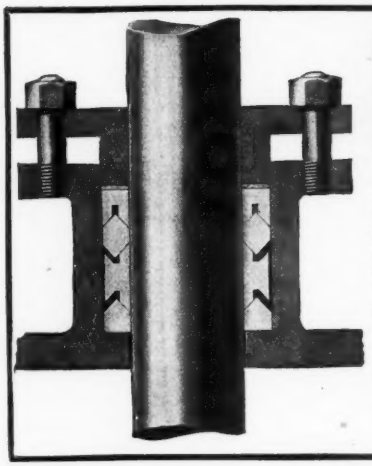
STEEL MILL PACKING CO., Detroit, Mich., U.S.A.



STUDY LAW

Improved Metallic Packing. No springs are required; has bearing on rod with only one-half the rings; used in any stuffing boxes; provides perfect lubrication; easy to install. *Write.*

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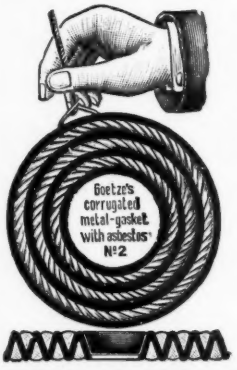
Sole Manufacturers,
113-121 FIFTY-THIRD STREET,
BROOKLYN, N. Y.

Unfinished Flange Surfaces



are the hardest to pack Goetze's Elastic Copper Gaskets will pack them where no other will hold.

WRITE FOR DETAILS.

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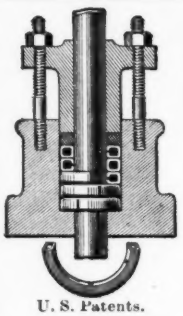

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PERFECT ROD LUBRICATION

is provided by **Huhn Metallic Packing.** It is filled with lubricating material which escapes in just the right amount.

WRITE FOR SAMPLE AND BOOKLET.

American Huhn Metallic Packing Company,
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Tough Pliable Elastic

These Packings are guaranteed free from acid, grit or any other agent destructive to the rod.

Where we once fill an order we always get a reorder.

Write for a circular.

Randolph Brandt
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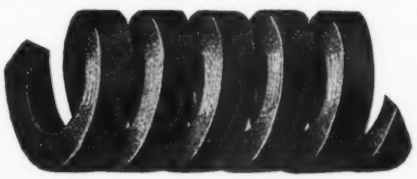

HONEST MATERIALS WIN

in the long run. That's why Johnson's Packings win out in every efficiency test against packings made by secret processes and doubtful formulas. We make packings for all purposes. *Write.*

THE HENRY JOHNSON COMPANY,
175-187 Gates Avenue, JERSEY CITY, N. J.

Many A Man

pays for steam he never gets, *that's when you are buying* it; and many a man gets steam he never pays for, *that's when you are selling.*

This meter is also adapted to the measurement of water, of air and other gases.

G. C. ST. JOHN
140 Cedar Street, NEW YORK

The St. John Indicating and Recording Steam Meter

The Perfect Polish

U. S. Metal Polish imparts a lustre that doesn't wear off. Applied easily and quickly. Sample free.

3-oz. Box for 10 Cts.
5-lb. Pail, $1.00.
1 gal, liquid, $1.00,
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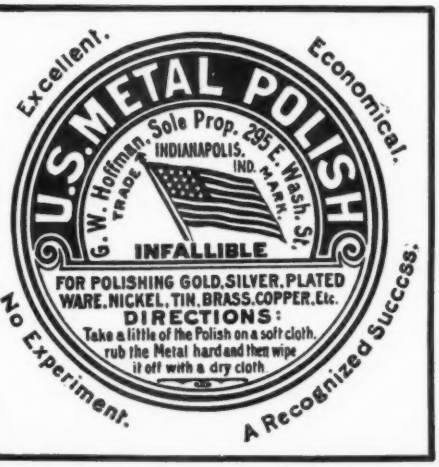
GEO. W. HOFFMAN,
Expert Polish Maker,
295 E. Washington St.,
INDIANAPOLIS, IND.
Branches: New York City; Chicago, Ill.; San Francisco, Cal.


Excellent.
Economical.
U.S. METAL POLISH
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INDIANAPOLIS, IND.
TRADE MARK.
INFALLIBLE
FOR POLISHING GOLD, SILVER, PLATED WARE, NICKEL, TIN, BRASS, COPPER, Etc.
DIRECTIONS:
Take a little of the Polish on a soft cloth, rub the Metal hard and then wipe it off with a dry cloth
No Experiment.
A Recognized Success.

BELMONT 1903 EXPANSION

Style 1 **PACKING**

BELMONT 1903 EXPANSION

STYLE 1

is the slickest thing in the packing line ever made. Its great advantage over all others is

The *Three Break Joint*, and you can see from the cut just how it works. The two sliding wedges are independently movable within the casing; before placing the ring in position pull one forward and the other one back. In position then, the ring is practically solid, and one ring of BELMONT EXPANSION No. 1 will prevent escape of steam or ammonia as effectively as three rings of any other packing.

The sliding wedges offer another advantage in that very slight gland pressure causes them to slide over each other and hug the rod tightly. Gives 50% draw as against 10% in solid packings.

For shallow stuffing boxes BELMONT EXPANSION PACKING is a positive necessity, and for any conditions of steam and ammonia service up to 125 lbs. pressure its use means *economy* and *convenience*. Write for booklet *A*. and a free sample. (For pressures exceeding 125 lbs. use BELMONT HIGH PRESSURE No. 50. Booklet *B*. and sample free on request.)

FREE Send for sample ring and be convinced. **FREE**

CLEMENT RESTEIN CO., Philadelphia, Pa.
Gentlemen:—Send me a sample ring of Belmont Expansion Packing No. 1.

Name .....
St. No. ..... Town ..... State .....
Firm Name .....
Number of Engines .....
Number of Pumps .....
Number of Boilers .....
High or Low Pressure .....
Packing now in use .....

POWER, Dec. 1, '08

CLEMENT RESTEIN CO.,
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Mfgrs. of every variety of Packing and Gaskets. General Catalog on request.

Salesmen Wanted

To call at power plants, pumping stations and engine rooms and sell BELMONT PACKINGS and Specialties. Particularly attractive proposition for manufacturers, agents and engineers in territory not already covered.

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THE PACKING WITH REAL HOLDING QUALITY

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DODS Diagonal Piston Rod Packing

is all one piece, made from high-grade Rubber and Duck in layers placed at a diagonal from every side. This construction gives "Dods" a cross expansion of 100%. It will hold steam, air or liquids when all other packings fail.

Send for test samples and description. Address Dept. P.

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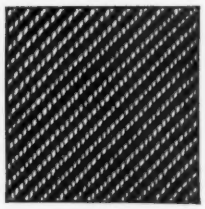
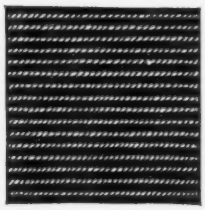


"DODS" PACKING.



ORDINARY PACKING.

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Sterling Metallic Packing for Any Pressure

It is made in three section rings, each of which is a valve seat in itself, elastic and easily worked. It keeps the rods smooth, will not corrode them when engine is idle and lasts as long as the engine. Every bit of it is absolutely guaranteed and sold on trial. Ask for the catalog.

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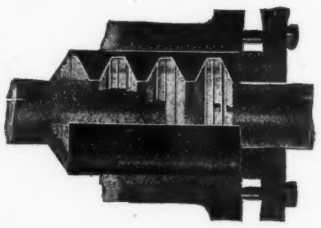

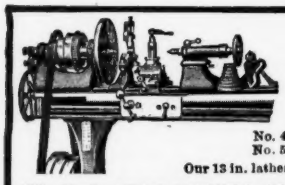

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W.F. AND J.C.

9 in. to 13 in. Swing.

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Our 13 in. lathes made 5 to 10 feet long. Send for lathe catalog.

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Perfect for high pressure. Semi-metallic, packs like fibrous packing, wears like metallic and gives more satisfaction than either. Ask us just how it is made, or, better yet, get a sample and see for yourself.

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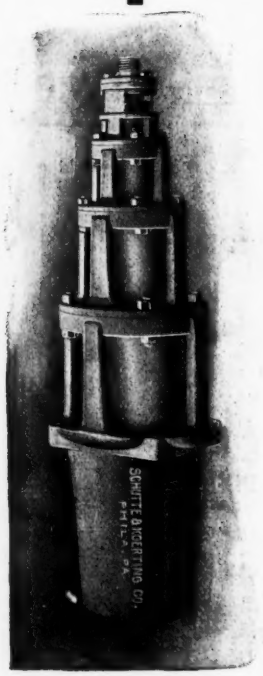
Koerting Chimney Ventilator



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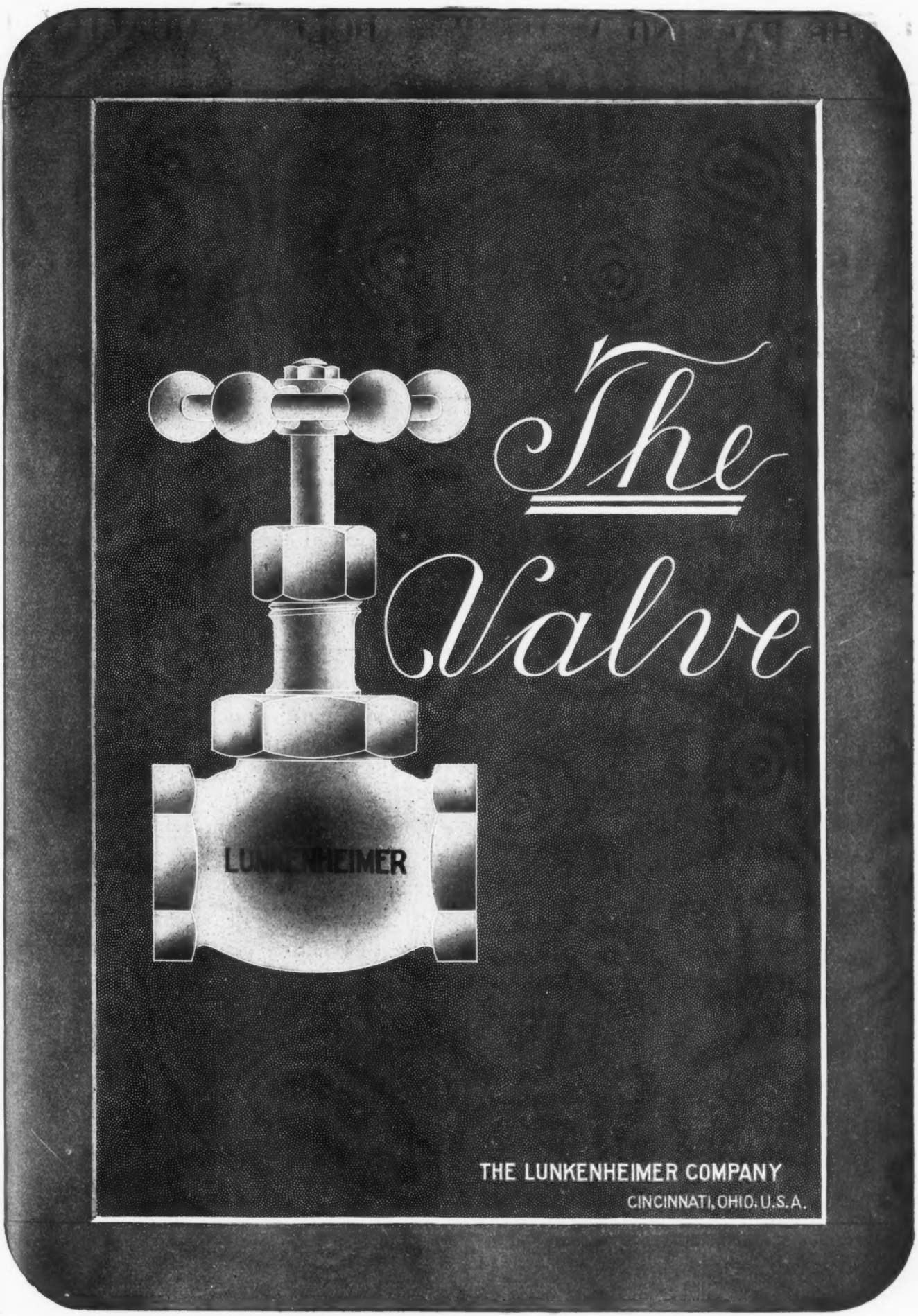
The Valve
THE LUNKENHEIMER COMPANY
CINCINNATI, OHIO, U.S.A.

Valve-Setting

By HUBERT E. COLLINS

Engineers are expected to know valve setting thoroughly. Half-way knowledge won't pass muster; haphazard methods are worse than none. Employers are demanding a thorough knowledge; license examiners are laying great stress on the subject. There has for a long time been need of a book giving simple, practical instructions in the setting of valves for all kinds of engines. We have published the book. Recognizing the fact that the fundamental principles of all valve design are contained in the slide valve movement, the first three chapters of the book are devoted to that subject. Afterwards a general idea of the Meyer valve movement is given and then the Corliss. Chapter IV gives general rules for finding crank and eccentric centers which can be applied to any make of reciprocating engine. Careful consideration of the first five chapters will enable a man to grasp any other part of the book where special makes of engines are described. The entire contents have been passed upon by *Power and The Engineer* editors and by the builders themselves. If you are at point where you want the most and best practical information on valve setting, you'll get this book and examine it. You can't risk a cent. *Guarantee*: Send us the price, $2.00. Return the book within five days of receipt if you're not entirely satisfie d and we'll refund your money. 209 pages, 6x9, 200 illustrations, cloth bound, $2.00 postpaid.

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Strength and Harmony are suggested by their appearance.

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Each valve is guaranteed, absolutely and expressly.

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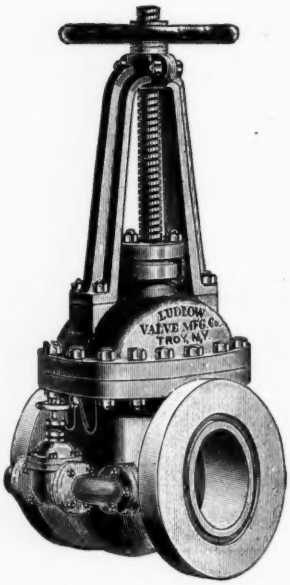

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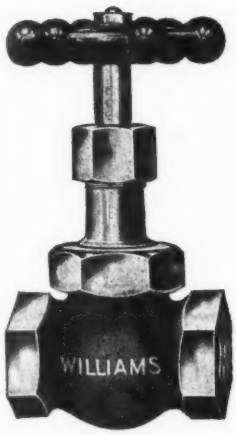
For Economy's Sake Use Williams Valves.



MODERN engineering practice has clearly demonstrated that the *regrinding valve* is the most economical, because it successfully controls steam or liquids at high pressures and temperatures without the difficulties experienced with other types of valves.

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Let your next order read—WILLIAMS.

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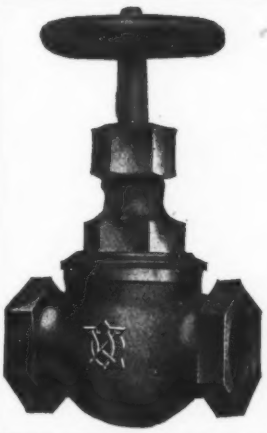

It's The Disc of the Kennedy Valve

that makes it impossible for leaks to occur. These discs are made of a special compressible composition that easily conforms to all uneven surfaces. They are renewable, too. Let us send catalog.

The Kennedy Valve Mfg. Company,
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MOUND TOOLS. FOR THE ENGINE ROOM.
This cut represents our new set of 20 tools gotten up for use in the engine room. Strictly high-grade tools with all the good points of toolsmithing in their make-up. Conveniently arranged in finished Oak Case and every tool is guaranteed.
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are different—because they're better, and better because they're different. Write for details.

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We employ over 1250 men in the manufacture of Ice and Refrigerating machinery exclusively.

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Our fittings carried in stock at the following places:

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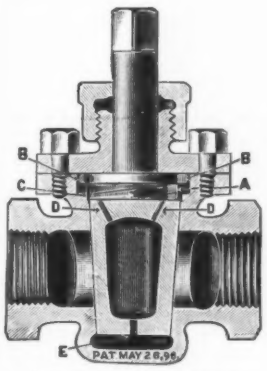
Quick Action



Homestead Straightway Balance Plug Valve Locks by Quarter Turn.

is a strong feature of our

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They are opened or closed by a quarter turn. The seat is absolutely protected from wear when pressure passes through; plug is balanced and held in place by pressure when open, and when closed is locked in the seat by our patent wedging cam, insuring freedom from friction in seat while plug is turning.

Homestead Valves are the quickest acting, simplest, easiest operated and most durable ever made.

Send for booklet and learn all the features.

HOMESTEAD VALVE MFG. CO.,
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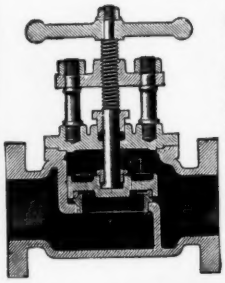
"BELLVILLE VALVES"



have the seat on the outside of an inverted cone where the direct current of steam does not come in contact with it, preventing all chance of wire drawing. Other features in catalog.

Heavy, Compact, Durable,
no marring by pipe tongs.

Eastwood Wire Manufacturing Co.,
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Over 600,000 of Kunkle's Patent Lock-up Pop Safety Valves now in actual use.

For Portable, Stationary, Locomotive and Marine Boilers. They meet every requirement. We also make Mufflers for Locomotives. Write for details and prices.

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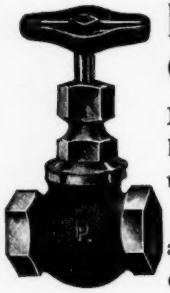
Insist on Pittsburgh Valves

and Fittings. It is impossible for human skill to produce better or more reliable equipment than that stamped with the sign of quality—"P."



Pittsburgh Brass Globe Valves

Made in a superior manner of the highest grade steam metal and sold under our binding guarantee.

If better work and longer life mean anything to you, insist on "P" products.

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WE MANUFACTURE ALL KINDS OF VALVES AND FITTINGS.

The Spring Seat of the Crosby Valve

TRADE MARK CROSBY

prevents jamming when the valve is closed and accommodates any variation of temperature.

We make these valves in either iron or brass, globe and angle styles for high or low pressure, and for superheated steam.

Ask for the Catalog.

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At The Sign Of The Whale You Should Buy Your Valves

New Bedford Whale Brand Valves are most carefully made, by valve experts, with seats and discs of Nickel Bronze. They are positively guaranteed to stay tight under all conditions. Ask for complete catalog.

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Established 1872
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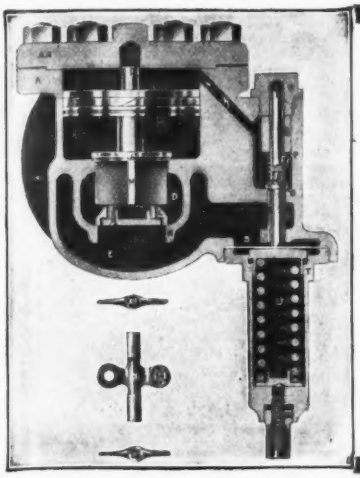

OUT OF THE PATH OF INITIAL STEAM

EVERY ENGINEER WHO HAS HAD TROUBLE WITH REGULATING VALVES, ON ACCOUNT OF CHIPS AND SCALE INTERFERING WITH THE OPERATION OF THE CONTROLLING VALVE, WILL INSTANTLY REALIZE THE BIG ADVANTAGE OF THE COLLIN REGULATING VALVE IN WHICH THIS VITAL PART "O" IS ABSOLUTELY PROTECTED FROM FOREIGN MATTER. - - - - - -

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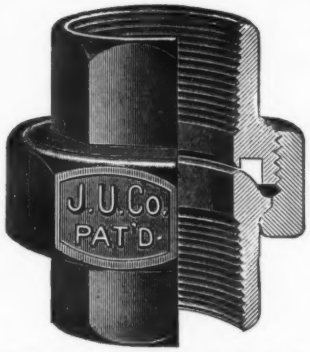

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It is made of malleable iron, with brass seat, and can be used over and over again. Tight joints are insured *always*—on steam, water, oil, air or gas connections. *Write for circular.*

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Cushioned Non-Return and Triple Acting
"Works Both Ways"

"The Life and Property Insurance Valves"

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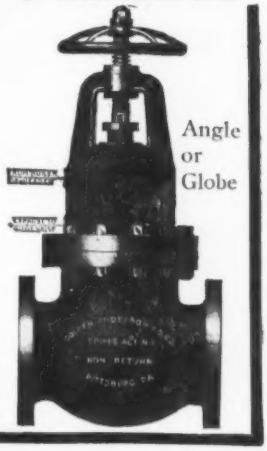
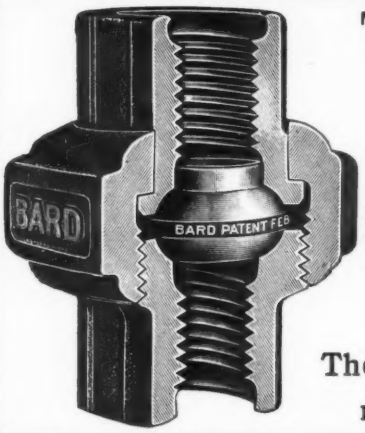


Angle or Globe

GOLDEN-ANDERSON VALVE SPECIALTY CO.
1017 Fulton Building, Pittsburg, Pa.



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holds pipe joints perfectly tight and leakless. The recessed ends positively prevent spreading.

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The Bard Union Co.
INCORPORATED
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You'll Need No Gaskets

With "Kewanee" Unions.

"KEWANEE"
"The union with no inserted parts."

Their ball-joint seat and brass-to-iron contact insures an AIR tight joint. You'll need no gasket—whether your pipe is in perfect alignment or not. The brass-to-iron thread connection means no corrosion in the thread—quick disconnections—time and labor saved.

Ask for convincing literature of full line.

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That's one proof of the superior value of the famous

Hercules Seamless Copper Floats

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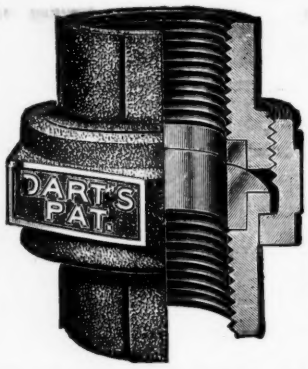

This is the Union with

"INSERTED PARTS,"

an excellent thing, that has forced its sting into a competitor and made him sing, "No Inserted Parts for him." The Union of "Inserted Parts" takes the lead. It's incomparable.

Catalogue ready for you.

Manufactured by the

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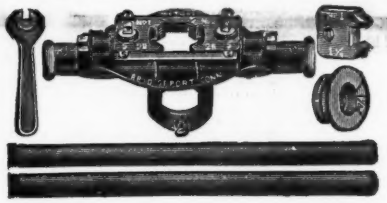

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All leading jobbers sell them.
Genuine ARMSTRONG TOOLS
made only by

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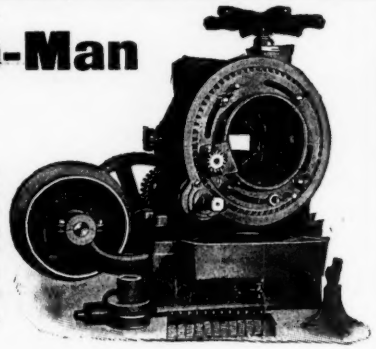
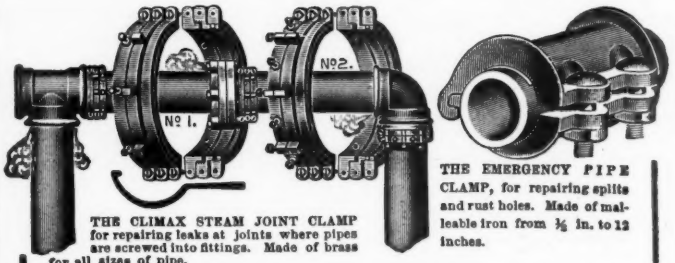
The One-Man Forbes

Patent Die Stock is the only machine that enables one man to cut and thread pipe up to 15" diam. by hand. The shell can be adjusted to take up the inevitable wear. Catalog?



The Curtis & Curtis Company, 85 Garden Street, BRIDGEPORT, CONN.



THE CLIMAX STEAM JOINT CLAMP for repairing leaks at joints where pipes are screwed into fittings. Made of brass for all sizes of pipe.

THE EMERGENCY PIPE CLAMP, for repairing splits and rust holes. Made of malleable iron from ⅛ in. to 12 inches.

PIPE REPAIRS FOR ANY CONDITION

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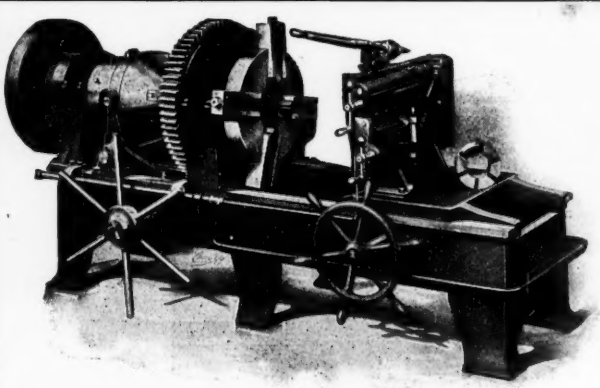
MANUFACTURERS,
61 West Washington Street, Chicago.



Pipe Machines For The Power Plant

We can furnish any size your plant may require, either belt or motor drive, and we want your inquiries.

Get the Catalog No. 17.

Bignall & Keeler Mfg. Co.
Edwardsville, Ill.

We Want

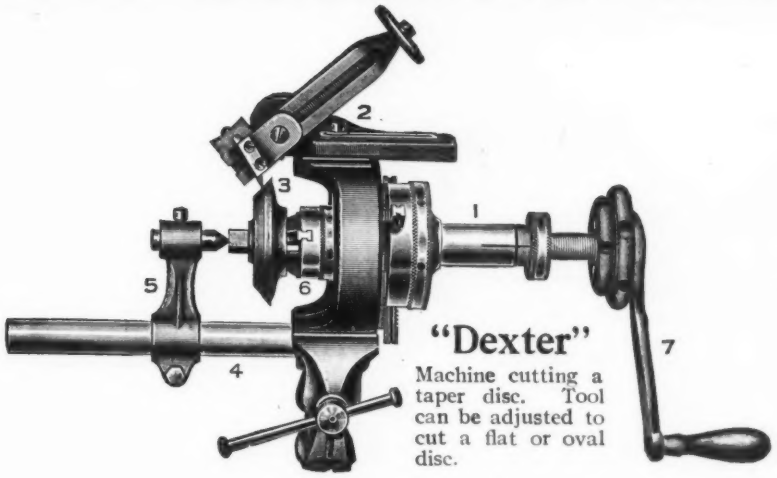
Photographs

of

Toledo Pipe Threading Devices

being used under difficult or unusual circumstances. ¶ We are willing to make it worth while for you to furnish us one. ¶ Write us for detailed information.

The Toledo Pipe Threading Machine Co.,
Toledo, Ohio



"Dexter"
Machine cutting a taper disc. Tool can be adjusted to cut a flat or oval disc.

Get This Machine On 30 Days' Free Trial

Many valves suffer from premature old age simply because the valve seats are worn and need recutting.

Perhaps there are enough such in your scrap pile to pay for a "Dexter" Machine.

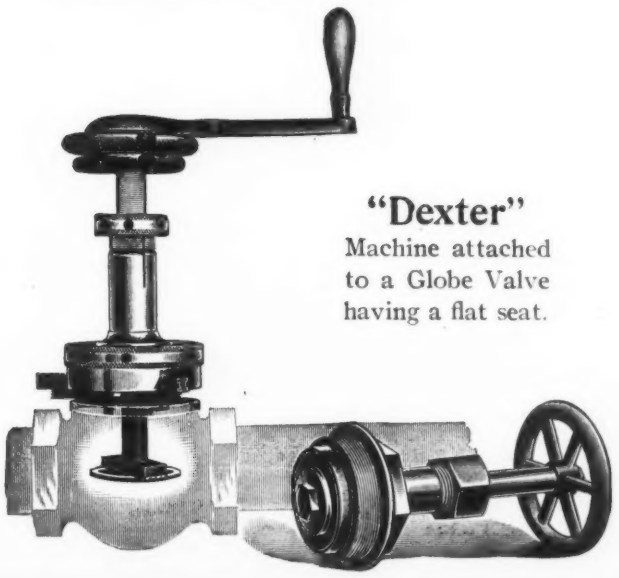
Each of these discarded valves can be recut eight or ten times, if you use our Reseating machine, and each time the valves are good as new.

It will also recut the valves now in use and that without disconnecting.

Get our catalog "P" for full details.

The Leavitt Machine Company,

Orange, Mass., U. S. A.



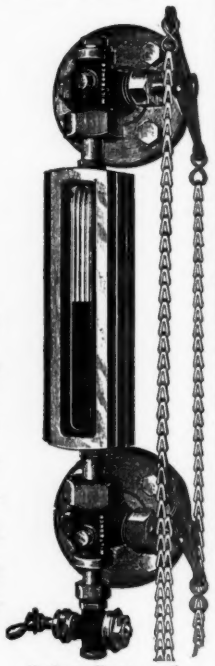
"Dexter"
Machine attached to a Globe Valve having a flat seat.

The Black Hand

Points To The Black Water

in the "Reflex" Water Gage—you can't mistake it. There's no straining of the optic nerve necessary here—a glance shows the reading. It's all because **the water shows black.** Accuracy and reliability are guaranteed.

CATALOG?



Reflex Gage and Wiltbonco Fittings

Jerguson Mfg. Company
219 Columbus Ave., Boston, Mass.

Pull The Chain

When The Glass Breaks

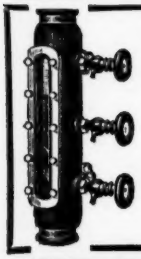
and save your hands and arms from being scalded—that's all you need to do if you have

The "P. B. H." Quick Closing Water Gauge

Standing a safe distance away you can simply and easily pull the chain and both water and steam will be shut off instantly.

Will you try one for 30 days, free?

The PAUL B. HUYETTE CO.
2025 Betz Building, Philadelphia, Pa.



RELIABLE

WRITE.

RELIABLE WATER GAUGE CO.
1616E Pine St., St. Louis, Mo.

Erwood Swing Gate Valves

Manganesite Paste for Joints

WALCH & WYETH, 87 Lake St., Chicago.

Your Fingers for Tools

They're all you need to pack your glasses tight with Gilbert Gauge Glass Preservers. No wrench is necessary. See how time and trouble are saved? Circular?

R. F. MORSE, Providence, R. I.

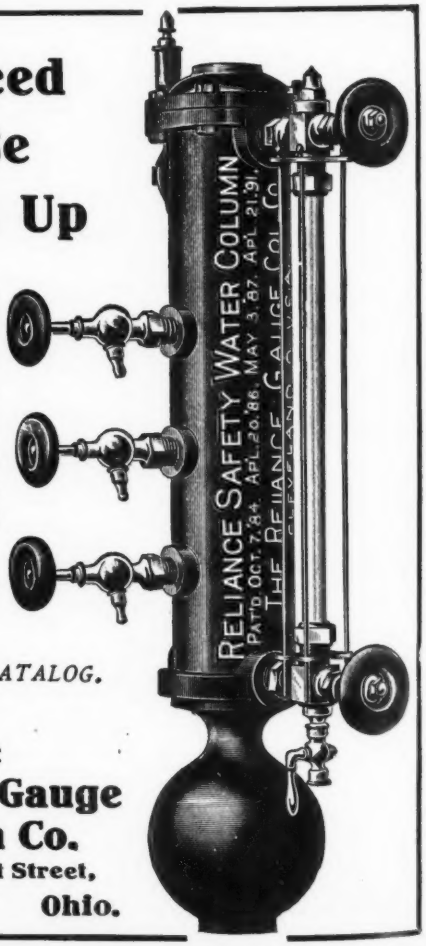
What You Want

to know about steam pressure is told by Ashton Gages. Their accuracy can never be questioned. *Write.*

THE ASHTON VALVE COMPANY, Boston, U.S.A.
NEW YORK St. John's House, London, Eng. CHICAGO

No Need To Be Blown Up

either by an exploding boiler when the water runs low or by the boss when the water runs high and wastes fuel.



WRITE FOR CATALOG.

The Reliance Gauge Column Co.
75 E. Prospect Street,
Cleveland, Ohio.

Beats all others combined and has none of their faults

Owning up to the "Old Man" that the belting slipped and burned is an unpleasant experience for any engineer. It hurts his pride, spoils his chance for a "raise" and costs the concern money in lost power and leather.

Schieren's Flyfoot Belt Dressing absolutely prevents slippage—but not in the STICKY way. More, it preserves the belting.

Send $2.00 for a five-pound tin of "Flyfoot." Give it a fair trial. If you don't want to keep it, return it and your money will go back to you.

Chas. A. Schieren Company
ESTABLISHED 1868.

Tanners,
Belt Manufacturers,
69 Cliff Street,
New York.

Pittsburg, 240 Third Ave.
Boston, 186-188 Lincoln St.
Chicago, 84-86-88 Franklin St.

Hamburg, Germany, Auf dem Sande 1.

Denver, 1622 Wazee St.
Philadelphia, 226 N. Third St.
Brooklyn, N. Y., 13th St. and 3rd Ave.

Oak Leather Tanneries, Bristol, Tenn.

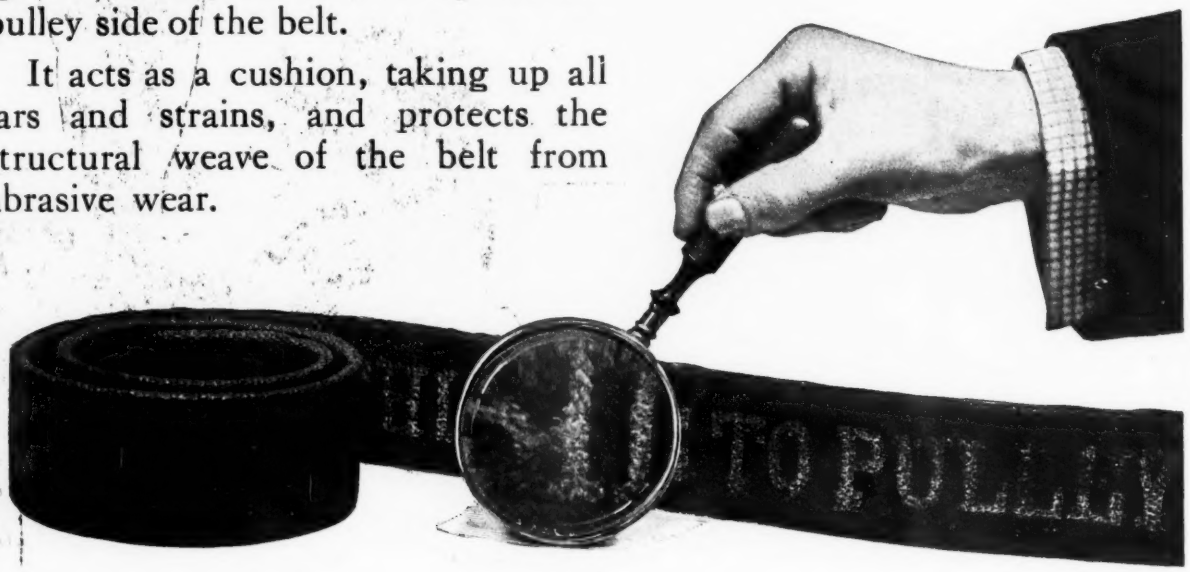
The feature of

Viking (*Solid Woven*) Pile Face Belting

which makes it superior to any other solid woven belt is the *pile* face.

This *pile* surface consists of an extra warp of specially prepared and spun cotton yarn thrown up on the pulley side of the belt.

It acts as a cushion, taking up all jars and strains, and protects the structural weave of the belt from abrasive wear.



It will do the same work, run considerably slacker and last longer than a belt without the *pile* face.

It does not shed while running under any conditions and effectively withstands heat, cold, steam, acid, water or chemical fumes.

It will outlast two or three ordinary belts.

Write for full Details.

New York Leather Belting Co.

Manufacturers

Highest Grade Oak Bark Tanned Leather Belting and Lace Leather

"C. F. A." (*Patent*) Laminated Leather Belting

Viking (*Solid Woven*) Pile Face Belting

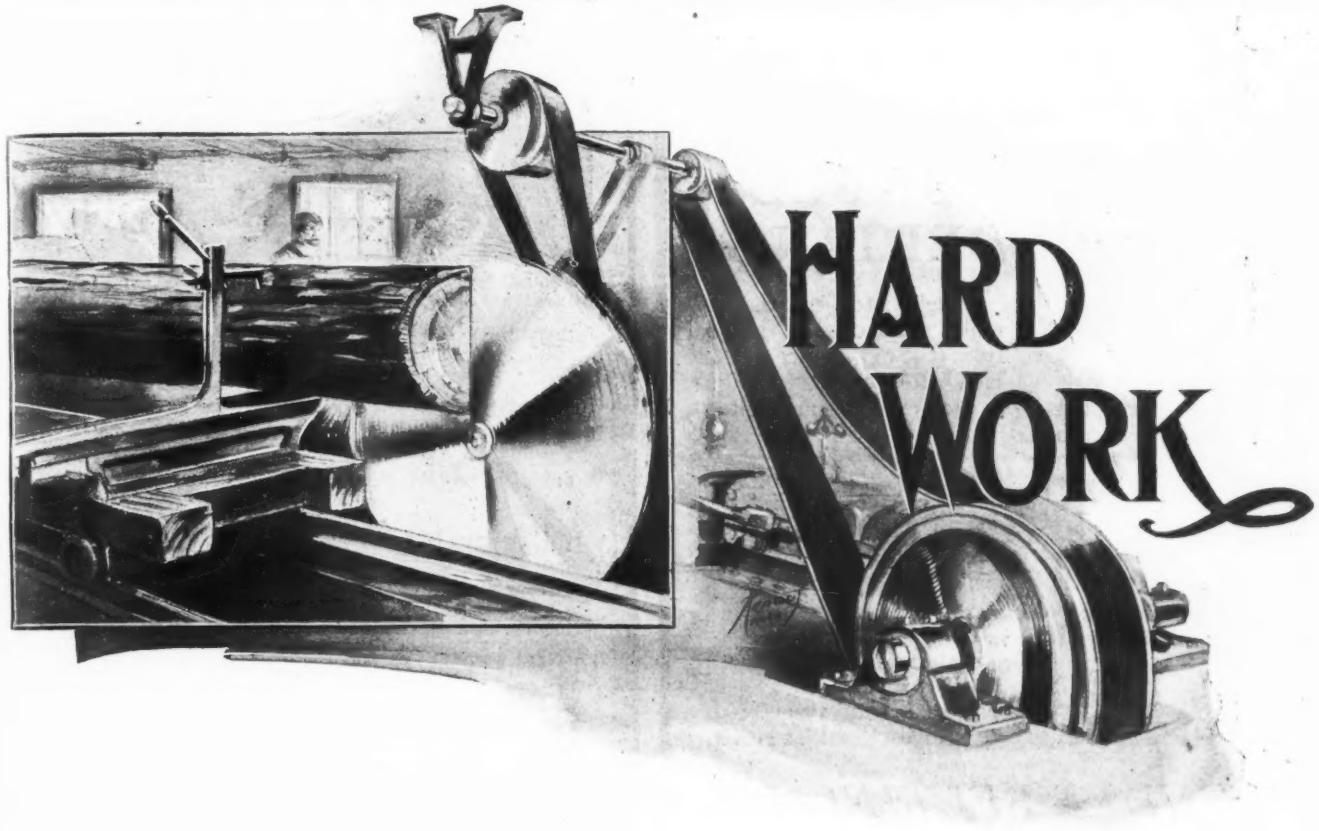
Victor Balata Belting

Victory Canvas Stitched Belting

Factories: Brooklyn, N. Y.

Offices and Salesrooms:

New York, N. Y., 51 Beekman St. Chicago, Ill., 44 Franklin St.



In some drives only the best belts can meet the conditions.

RHOADS LEATHER BELTING

stands up to such work and gives full measure of value in service.

J. E. RHOADS & SONS

PHILADELPHIA: 12 N. Third St. NEW YORK: 40 Fulton St.

BOSTON: Hamblet & Hayes Co., Eastern Agents, 105-111 Summer St.

FACTORY AND TANNERY, WILMINGTON, DEL.

HAVE YOU TRIED

SHULTZ SABLE BELTING?

Whether or not it will make good can be judged from the experience of Mr. H. W. Rice, Mgr., J. Wilbur Co., Philadelphia, who writes us (unsolicited) under date of Sept. 4th, 1908:

"Some time ago we wished to determine what belting to adopt. We placed three belts of the best makes on machines running under identical conditions, which were very severe.

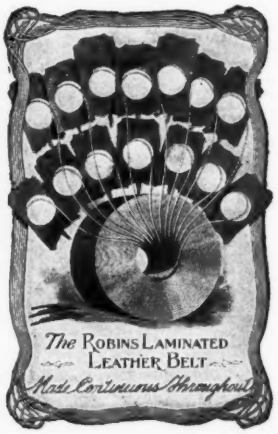
"We are replacing one of the other belts with a new one of yours, while the old one of your make is yet in good condition."

Sable Belting will save money for you, too, if you give it a chance. Write for booklet No. 4.

SHULTZ BELTING CO.,

ST. LOUIS, MO.

NEW YORK BOSTON PHILADELPHIA



Practically Akin to a Positive Drive

ROBINS LAMINATED LEATHER BELTING

The only logical choice between direct connection and the belt.

Indispensable for High Speed Heavy Duty Service

Made from continuous units cut in strands of full roll length from the finest selected oak tanned belting butts. The strands are cut to gauge and the width determines the thickness of the belt when they are laid on edge and laminated together. Every strand is stretched independently to the full elastic limit guaranteeing a belt which is practically *non-stretchable*. **NO LAPS, NO PLIES NO CEMENT**—joined endless upon the pulleys with a neat and simple splice which holds the gauge, balance and strength of the belt intact.

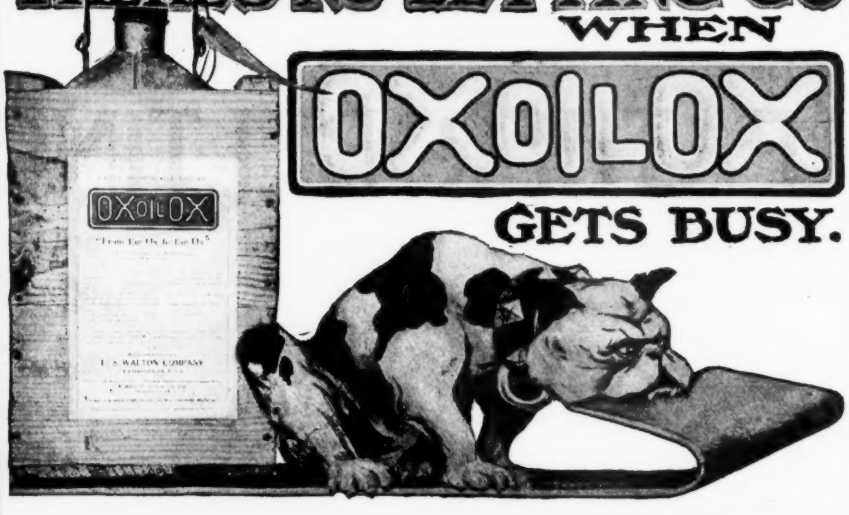
WRITE FOR CIRCULAR No. 2.

ROBINS NEW CONVEYOR COMPANY

Factory: 168 Duane St., New York.

New York: 38 Wall St. Chicago: Old Colony Bldg.

THERE'S NO LETTING GO WHEN OXOILOX GETS BUSY.



BUT IT'S THE BELT THAT DOES THE GRIPPING

If a belt has been thoroughly treated with **OXoilOX** you can't make it slip. Run it at full load and full speed—it clings to the pulleys like a chain to the sprocket. **OXoilOX** gives new strength to **old tired belts.** It drives out the "sticky stuff" with which they are usually saturated; makes them clean, pliable and tough. They do **more work** and do it **better.** For **new belts** the best possible start in life is a treatment with **OXoilOX.** It takes the stiffness out; restores the vitality lost in tanning, and helps them get right down to work. Whether old or new, a belt treated with **OXoilOX** adheres so closely to the pulleys that air is absolutely excluded and it's the vacuum thus formed that enables it to **run slack at full load without slipping.** Write for sample.

F. S. WALTON CO., Philadelphia.

Gentlemen:—Kindly send us free of all charge, a sample can of OXoilOX, the perfect belt dressing.

Name..... **Name of Firm .....**

Address..... **Number of Belts.....** **Average Size.....**

F. S. WALTON CO., Philadelphia, Pa.

Pressers and Refiners of all grades of Neatsfoot Oil.

Slack Belts

Why should you worry along with tight belts, struggling to keep them tight?

When the only reason on earth for the tension is to prevent slipping.

And that same tension is killing the belts, heating the bearings, straining the shafting and putting a dead drag on the engine and burning coal that does no one any good.

And all a useless waste when Cling-Surface will prevent the slipping better than tension can and make it totally unnecessary.

Cling-Surface will stop *all* slipping no matter what the belt or rope is, what position, what centers or pulleys, out-doors or in.

Every belt can be run easy or slack and carry fullest loads, with no hot bearings, less oil, ease on shafting, belt and engine.

And the belt pliable, clean, waterproof and preserved. No drying nor cracking, no running off but perfect service.

The best plants use Cling-Surface. We guarantee these results. Do you use it or do you still run your belts tight? What is the use? Write us.

Cling-Surface Company

1049 Niagara Street, Buffalo, N. Y.

New York, Chicago, Boston, St. Louis, Denver, St. Paul, Atlanta, Memphis, etc.

London, Thomas & Bishop, 119-125 Finsbury Pavement E. C.

Your Power Will Do 5 to 10 Times The Work

if you use Hercules Leather Covered Pulleys and thus prevent all belt slipping. Let us show you some actual records the Hercules Pulley Cover is making. Write us.

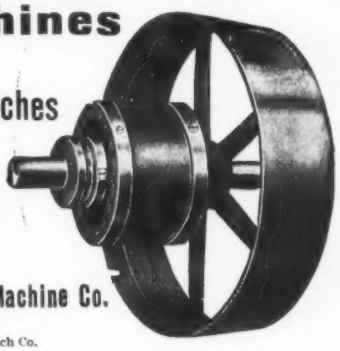
Hercules Pulley Cover Co.,

Detroit, Mich.

Lengthen The Life Of Your Machines

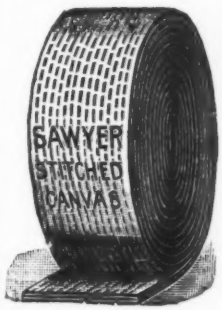
BY USING

Akron Friction Clutches



They start easily, gradually and without shock or jar. They are the best you can buy. Try one and see. Booklet?

The Williams Foundry & Machine Co.
AKRON, OHIO
Successors to the Akron Clutch Co.



Belting Logic—If best Leather Belting costs per sq. ft. $1.00, best Rubber Belting 60c., and best Stitched Canvas Belting 40c., and with Leather showing 25% and Rubber 50% of the strength of **Best Stitched Canvas Belting,** wouldn't it be good policy for you as a practical man to investigate the merits of our product? Send for Book "C".

Sawyer Belting Co.,

Cleveland, Ohio.

GENUINE
GANDY

Engineers—

Are You Looking For Trouble?

If you are, don't buy

GANDY RED STITCHED COTTON DUCK BELTING.

It never made trouble yet, and never will.

Runs *straight* and *true*; remains unaffected by *water*, *steam* or *acids*, and outlasts other belting.

First cost only ⅓ that of leather, and the saving has just begun.

Write for free booklet—

"Experiences With Gandy."

(New strength for tired belts: Gandy Belt Dressing.)

THE GANDY BELTING Co
BALTIMORE MD.

Over a Million

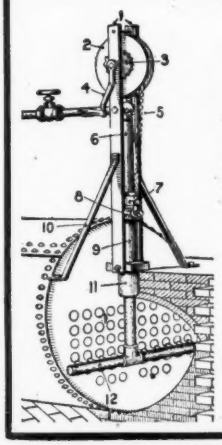
American Pulleys are in use and every one giving satisfaction.

They are strong, rigid, durable, true running and made to fit shafts of various sizes.

Sold by all supply houses.

Pat. in U. S and Foreign Countries.

The American Pulley Company
29th and Bristol Sts., Philadelphia, Pa.



The Henry Steam Flue Cleaner

cleans all the flues of a boiler absolutely clean in 5 minutes, by simply turning a crank and opening a valve. Every particle of soot is removed from the entire inner circumference of every flue and is blown up the stack.

BOOKLET?

The Henry Steam Flue Cleaner Co.,
Ashland, Wisconsin.

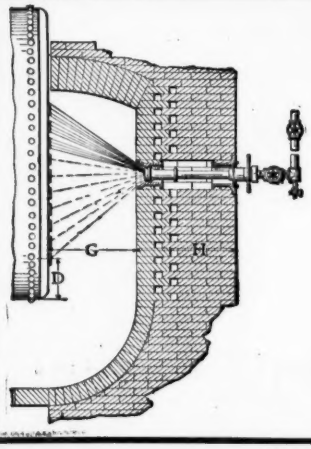
GET THE PHILIPS

The Philips Pulley once you try,
No other pulley you will buy.
All must admit this stubborn fact,
Its entire face gives belt contact.
No rivets penetrate the face;
The spider's strong, 'twill stand the pace;
The Philips Pulley, substantial and true
Is the proper pulley your work to do.

PHILIPS PRESSED STEEL PULLEY WORKS
4th Street and Glenwood Avenue, Philadelphia, Pa.

TRADE MARK

ASK FOR CATALOG



In The Direction Of The Natural Draft The Monarch Steam Flue Blower Blows The Soot

It sets in the rear wall of the boiler and works **naturally.** Cleans any size boiler perfectly in five minutes. Try a "Monarch" free for 30 days. **It's a big money saver**—you need it.

CIRCULAR?

The Monarch Steam Blower Co., Troy, N. Y.

Good salesmen wanted in territory not covered. Attractive proposition for hustlers.

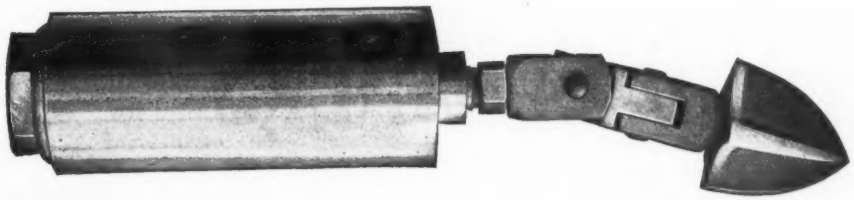
The End of Scale Is The Beginning of Economy

The Perfection Flue Cleaner is sent on 30 days' free trial and guaranteed to clean

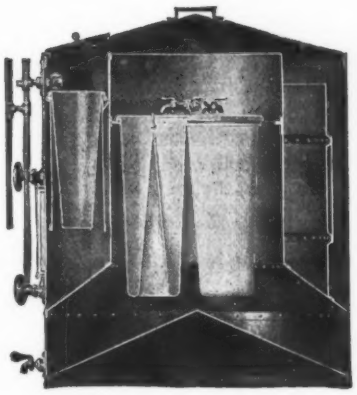
thoroughly, do no damage, prove self-sharpening and not get out of order. Write.

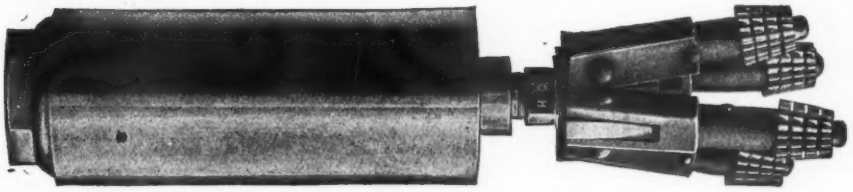
SCULLY STEEL & IRON COMPANY, Chicago.

J. B. HACKETT, 5 Temple Court, New York Representative.



LIBERTY DEVICES





PROTECT ON ALL SIDES!

The successful power plant man guards against three things:

The accumulation of scale in the boiler tubes.

The possible clogging up of his pumps, condensers and other machinery.

The waste incurred by throwing away dirty oil, and the injury to the machinery resulting from using same.

The Liberty Trio was designed to cope with just such conditions as these.

LIBERTY TURBINE CLEANERS for removing the thickest scale.
TWIN STRAINERS for *continuously* straining water.
LIBERTY OIL PURIFIERS for *refining* dirty oil.

Each Liberty Device performs its work better and cheaper than any other similar device on the market. *Catalog ?*

LIBERTY MANUFACTURING COMPANY

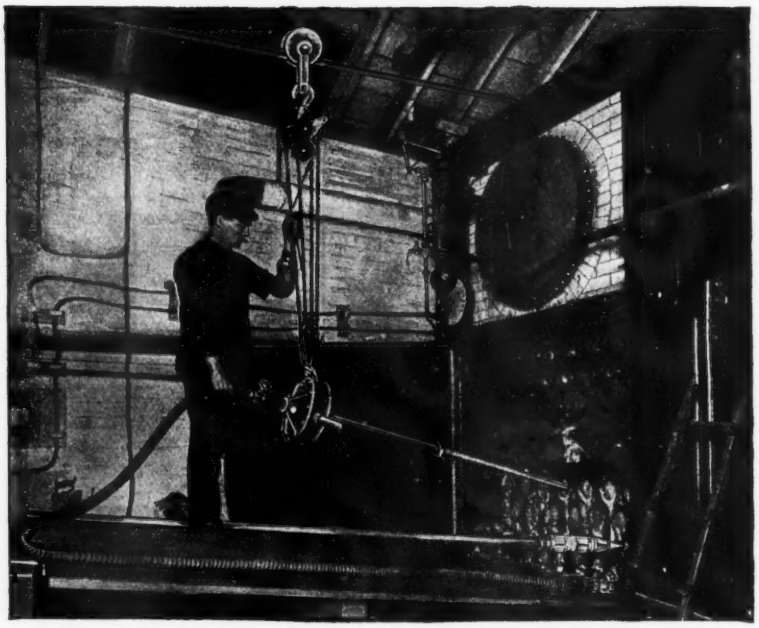
6509 Susquehanna St., Pittsburg, Pa.

WEINLAND CLEANERS ARE ALL RIGHT SAYS JOHN BULL

Mr. Percy C. Rycroft, Manager of Heston & Isleworth Urban District Council, writes to our London Office as follows:

"We have used the Weinland Power Cleaner at these Works with considerable success. Hard lime scale which the ordinary scraper would not touch, was readily removed, the machine cleaning the complete tube down to the metal in from 7 to 15 minutes.

"The operation is extremely simple, and in my opinion, it is a distinct advantage that no water pressure is required."



Weinland Steam or Air Cleaner removing ½ inch scale from one tube every 8½ minutes, at the plant of Foos Mfg. Co., Springfield, Ohio.

Weinland Boiler Tube Cleaners are in successful use in every civilized country. In Europe, in South Africa, in Japan and India, in Australia, "Weinland" stands for the most effective boiler cleaning apparatus, just the same as at home. No other cleaners have ever removed such hard scale, or stood up to constant hard service with so little sign of wear.

If troubled with boiler scale, let us help you. We have spent twenty-two years overcoming scale troubles and make cleaners for every scale condition, every power, every size of tube, and type of water tube boiler.

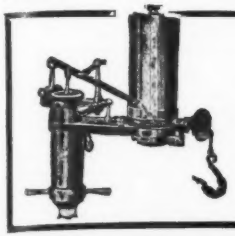
Ask about our Weinland Wing Head Cleaner, driven by turbine or air motor.

THE LAGONDA MFG. CO., Springfield, Ohio

Makers of Lagonda Automatic Cut-Off Valves, Reseating Machines and Tube Cutters

New York Philadelphia Pittsburg Chicago San Francisco Birmingham St. Paul Toledo London

(72)



No Larger Value

and no smaller price is to be found on any standard indicator. The Trill is cheapest by $50.

The Trill Indicator Company,
Eagle Street, Corry, Pa.

PURE WATER FOR THE BOILERS BY THE

WE-FU-GO and SCAIFE

Water Softening and Purifying Systems.

RESULTS GUARANTEED SEND FOR OUR CATALOG.

WM. B. SCAIFE & SONS CO.,

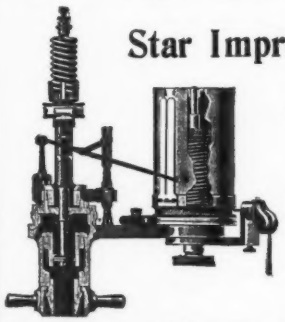
Founded 1802. PITTSBURG, PA.

A PERFECT INDICATOR

IS THE

Star Improved Outside Spring

Class B Style.



Suitable for.....
High Pressures,
High Speeds,
Superheated Steam,
and all uses where absolute accuracy is required.

A QUALITY INSTRUMENT.

Send for Circular.

Manufactured Exclusively By

Star Brass Mfg. Co., 108-114 E. Dedham Street, **Boston, Mass.**

No Other Compound is Warranted to do This

We absolutely warrant MAGIC BOILER COMPOUND to remove scale already formed in any boiler in any locality, in any water; to prevent more scale forming; to remove oil or grease; to stop minor leaks; to stop pitting and galvanic action; not to injure the metal in boiler; not to evaporate; not to affect the packing, lubricants or product of your plant which comes in contact with the steam; not to cause boiler to foam and not to injure any valves.

Magic Boiler Compound

will do what no other compound will do, because it works on a different principle. Its action is mechanical and not chemical. Iron, under heat, attracts MAGIC like a magnet does steel. It is drawn through the cracks in scale and works its way between the scale and the iron, coating it in much the same manner as cylinder oil coats the surface of a cylinder. This action loosens the scale and it drops off. The scale sediment can then be blown off or washed out.

We will send you enough MAGIC BOILER COMPOUND for a 60 days' trial with the distinct understanding that if it does not do exactly as claimed, in our warranty, when used according to directions, we will make no charge therefore.

Could we be fairer? Under these conditions you take no chance whatever.

Send today for special trial and booklet.

H. W. JOHNS-MANVILLE CO.

New York	St. Louis	Baltimore	Los Angeles	Milwaukee
Pittsburg	New Orleans	Seattle	Chicago	Cleveland
Kansas City	Dallas	Boston	Buffalo	Minneapolis
Toronto	Philadelphia	Detroit	San Francisco	London

868

It's Free!

IF you own or operate boilers, send for this 48-page book "Boiler Troubles and Their Prevention", which explains corrosion, scale, oil and grease deposits and what harm they may do. It further discusses every method of water treatment, gives valuable advice on feeding boiler compounds, the care of blow-off valves, etc.

If you want additional advice about your boiler troubles, send sample of your scale or feed water.

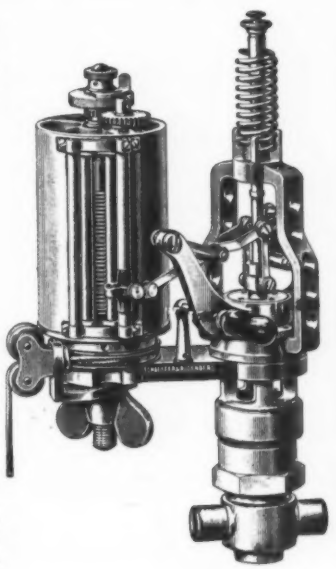
WRITE TODAY.

THE BIRD-ARCHER CO.,
90 West Street, New York. 18

All the Improvements

that tend to better indication, longer life and more convenient operation without unnecessary complication or expense.

The S. & B. Thompson Continuous Card Indicator



takes a roll of paper 6 feet long, which can be removed or replaced without removing the indicator from the engine.

It will take a record long enough to give really accurate information as no other indicator will.

Catalog?

The Schaeffer & Budenberg Mfg. Co.

Main Office and Works, 963-5 Kent Avenue, Brooklyn, N. Y.
Western Salesroom, - - 15 W. Lake Street, Chicago.

Down The Scale

If you get rid of scale effectively and permanently, you will get far better results from your boilers at much less cost. You can do it by using

Pyramid Boiler Compound

It is positively guaranteed to remove existing scale and to put the feed water in such pure condition that new scale *cannot* form. It hits the "disease" at its root. Let us analyze a sample of your scale and prescribe.

Some territory still open for agents of the $5000 class.

Binghamton Boiler Compound Company

Water Purifying Chemicals

Binghamton **New York**

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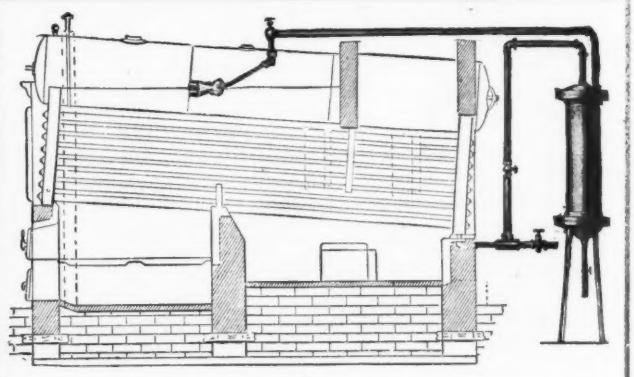

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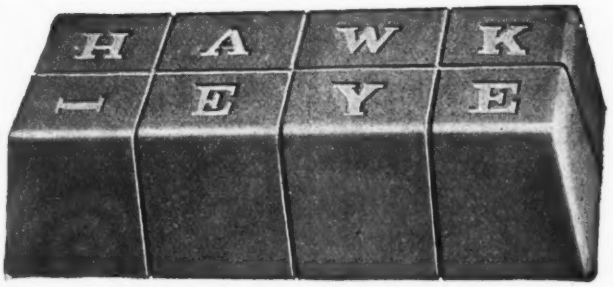

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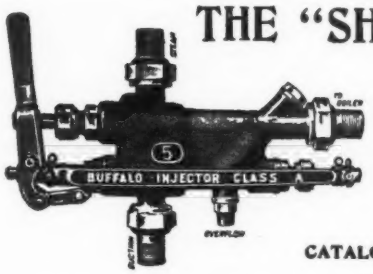

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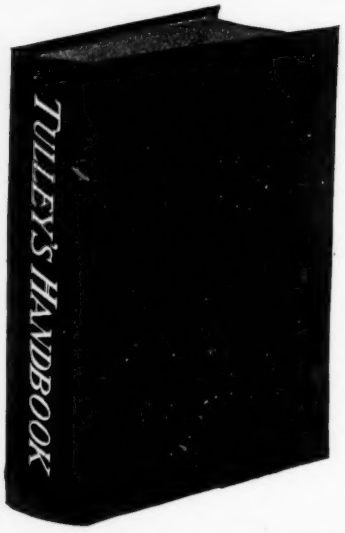

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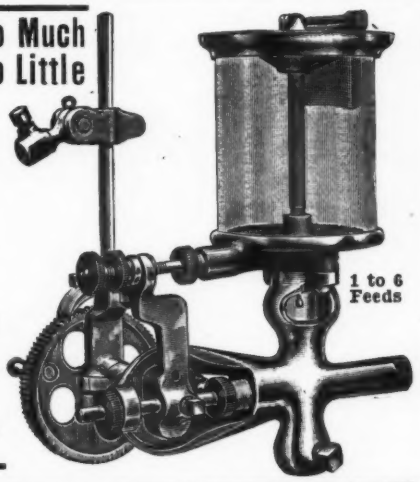

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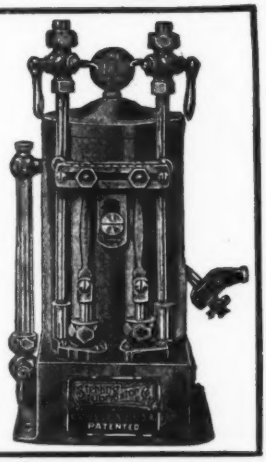

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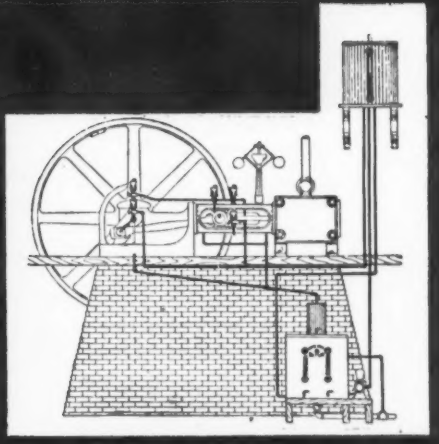

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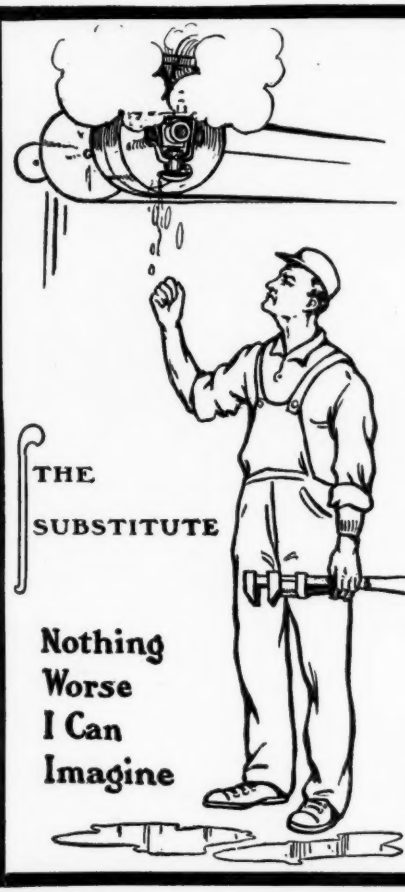

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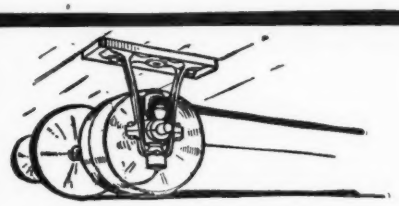

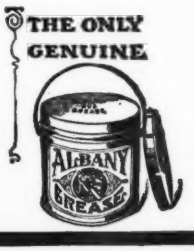

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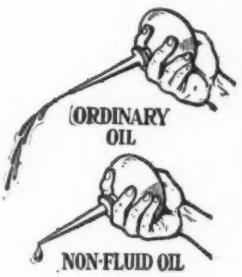

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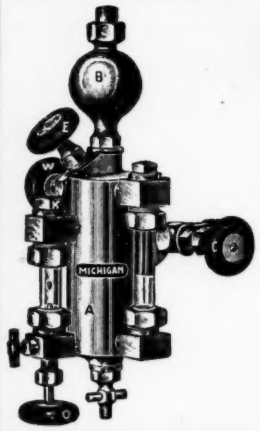

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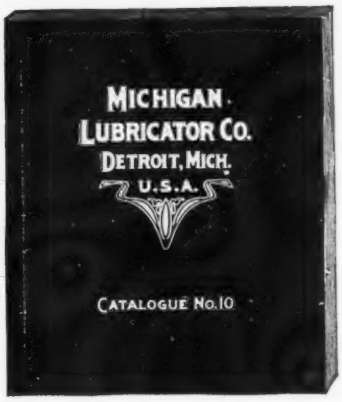

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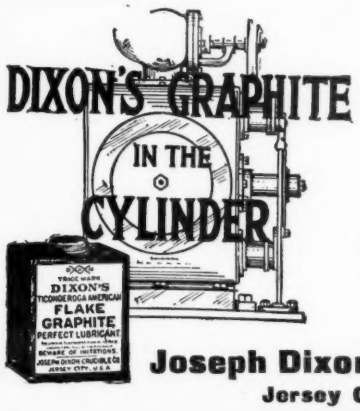

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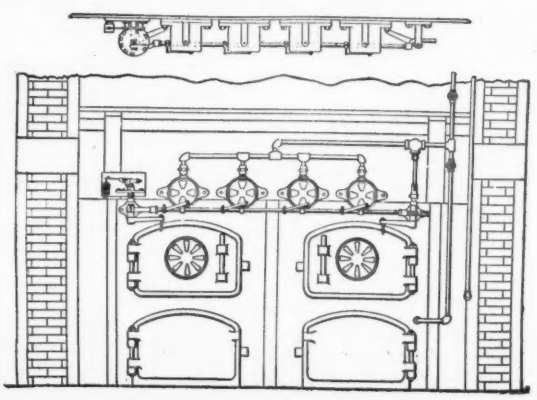

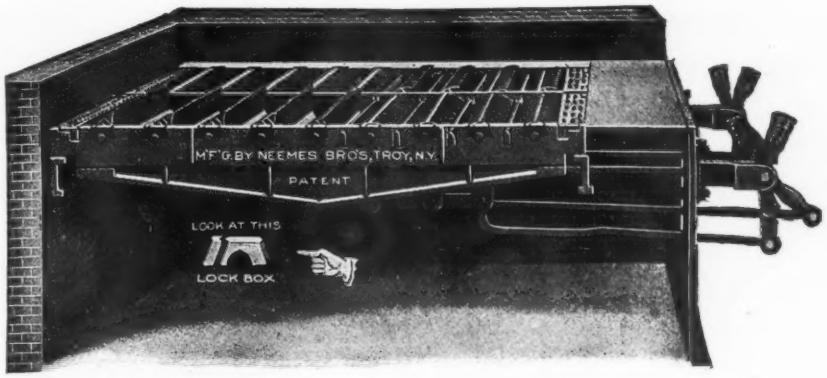

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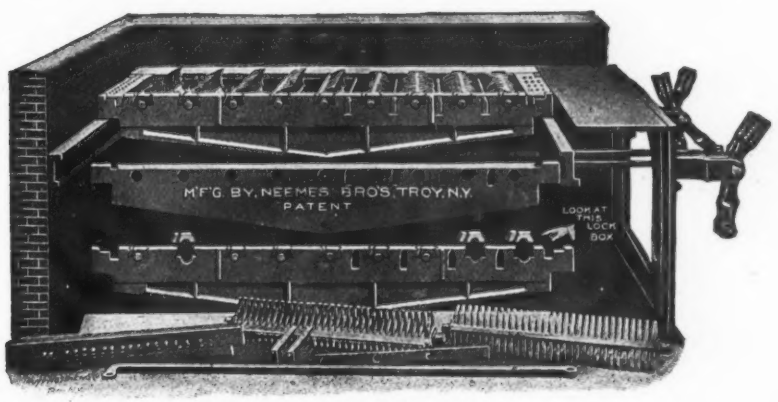

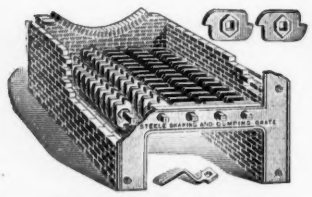

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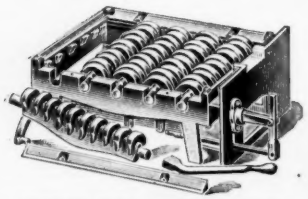

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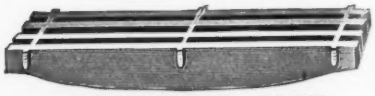

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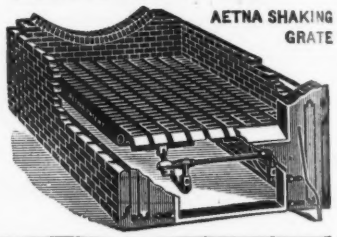

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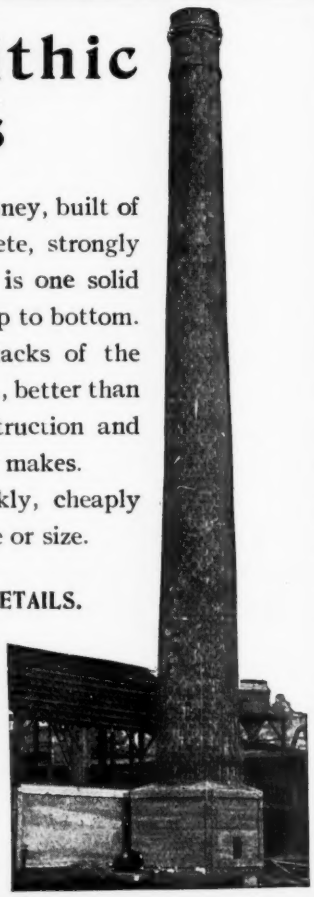

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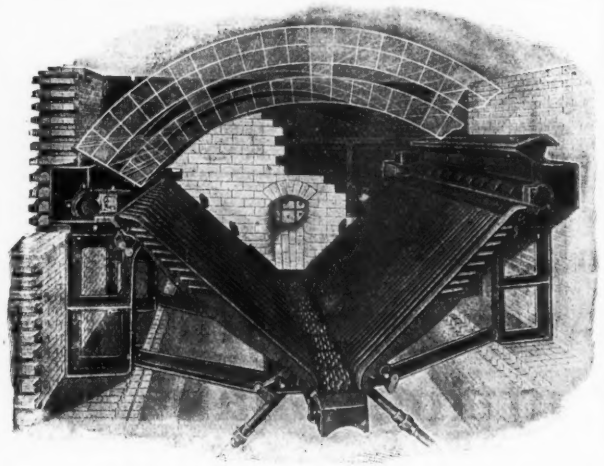

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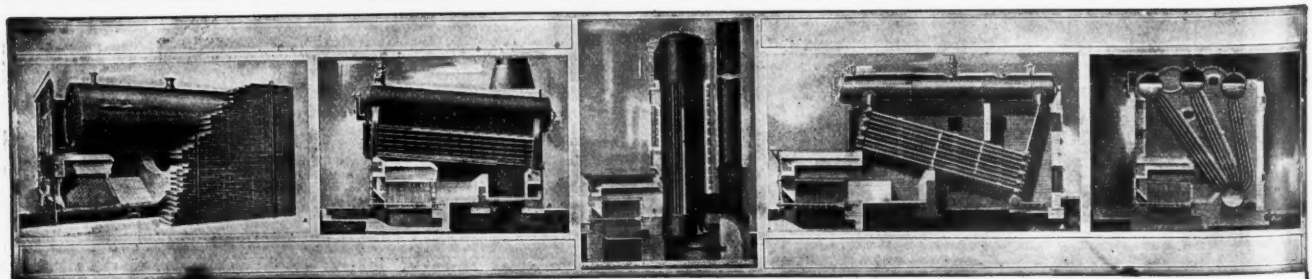

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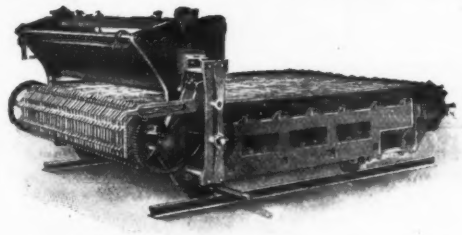

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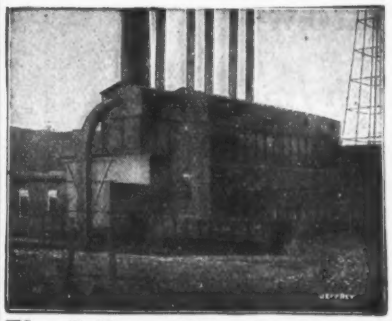
General Foundry Work a Specialty

A MODEL POWER HOUSE EQUIPMENT
Employing Jeffrey Machinery



Comprising complete system of Storage.

Hoppers with Pivoted Bucket Conveyer for handling coal and ashes.

Elevating, Crushing, Screening, Conveying. Catalogues free.

The Jeffrey Mfg. Co., Columbus, Ohio, U. S. A.
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Lasting Satisfaction

There is a LASTING SATISFACTION about using the best tools made—satisfaction to you—satisfaction to those who use the product of your labors.

Ask for Catalog No. 18AG—the catalog of "lasting satisfaction" tools.

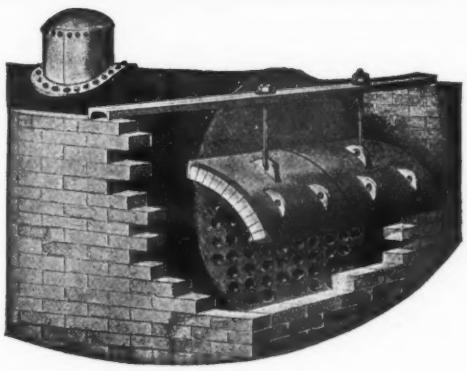
THE L. S. STARRETT COMPANY,
ATHOL, MASS., U. S. A.

If There's Smoke Coming Out Of The Chimney There's Soot Forming On The Tubes

of your boilers and every engineer knows that even a very light coating of soot will add a great deal to the plant's coal cost. The Wilkinson Automatic Stoker will solve the difficulty to perfection.

Write

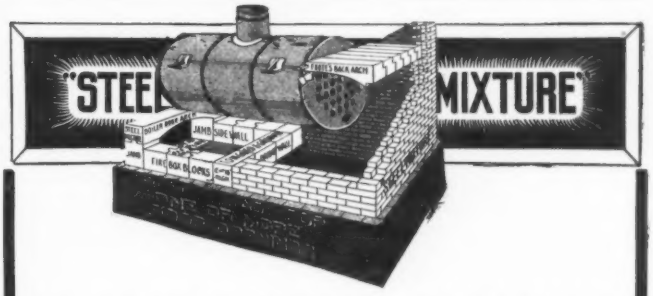
The Wilkinson Manufacturing Co.
Bridgeport, Montgomery County, Pa.



If You Have Trouble In Maintaining Your Brick Settings

and especially your rear arches, the Monarch Boiler Arch will completely overcome the difficulty. The illustration tells the story. Plenty of room for expansion of parts. You can try it before you buy it. Catalog ?

MAYVILLE SPECIALTY MFG. COMPANY,
General Founders and Machinists,
Mayville, Wis.



DO YOU REPAIR YOUR BOILER SETTING EVERY YEAR ?

It is not necessary, when you can get "Steel Mixture." If your boiler door arch falls in too often, if your fire box walls burn out too soon, or if your back combustion chamber arch gives you trouble, let us know. We have shown hundreds the way to boiler setting economy. Why not you ? Our boiler settings are Time, Labor, and Money savers.

When writing be sure and ask for "Dimension Booklet."

McLeod & Henry Co., TROY, N. Y.

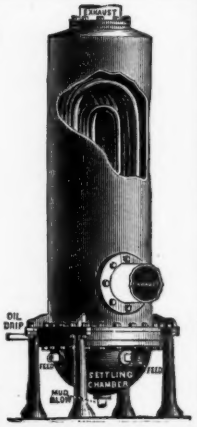
In 60 Days You Will Know

whether or not the

Patterson-Berryman Feed Water Heater and Purifier

will pay for itself in your plant—if you decide that it will not then return it to us at our expense. Shall we send it today?

Frank L. Patterson & Co.,
28 Cortlandt Street, New York, U.S.A.



Every Coil a Spring

Reilly Multicoil FEED WATER HEATER

IN AN ADVERTISEMENT we cannot describe all the advantages of this heater. We therefore ask you to write for our Catalog.

The GRISCOM SPENCER CO.
90 WEST ST., NEW YORK.

The Reilly Oil and Grease Exractor. | Agents: Russel Engines—Tudor Boilers Mfgrs: Tanks—Special Machinery of all kinds

MARTIN GRATES

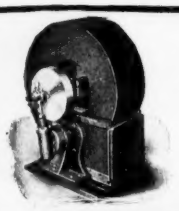
Martin Anti-Friction Rocking Grates will burn slack coal and get the same steam results as ordinary grates do with best lump coal. Catalog tells why.

MARTIN GRATE COMPANY, 281 Dearborn Street, CHICAGO.

A Protective Device

which *prevents* formation of scale in boilers—Advance Feed Water Purifier. Ask about it.

F. E. KEYES & SON, 20 Broad St., New York



Smokeless Furnaces, Mechanical Stokers, Grate-Bars, Rocking and Dumping Grates, Shaking Grates, Practical Oscillating Steam Engines.

Simple, durable and economical for all purposes.

PAUL L. CROWE,
47 Montgomery St. Jersey City, N. J.

We can elevate or convey your **COAL** a distance of 100 feet for less than **ONE CENT A TON**
in quantities of ONE TON A MINUTE or more.

Catalog Free.

THE C. O. BARTLETT & SNOW COMPANY,
Cleveland, Ohio.

Use Cheap Fuel

and the Wing Turbine Blower and you'll get highest grade results at a fraction of the usual cost. Details?

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C-O-Two Furnace Tile

The best fire arch making material ever devised. Lasts longer. Increases combustion. Write for full description.

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CONTRACTORS.
CENTRAL STATION HEATING.

Write for valuable information.

AMERICAN DISTRICT STEAM CO.,
Lockport, N. Y. Toronto, Can. Chicago.

"SIROCCO"
TRADE MARK

FANS AND BLOWERS

BUILT ON THE TURBINE PRINCIPLE

SIROCCO ENGINEERING CO., 138 Cedar Street, New York

Strong Fire Brick

Secure **"Presbrey's"** and your boiler settings will give you the *satisfaction that lasts*. Presbrey Boiler Door Arches and Jambs are standard and adapted to any type and size boiler. Write.

Presbrey Fire Brick Works,
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COES IMPROVED COMBUSTION AND DRAFT SYSTEM

GEO. H. THACHER & CO.,
ALBANY, N. Y.

GRATES OF ALL KINDS. BOILER CASTINGS.

STEAM PIPE COVERING

Magnesia, Asbestos, Air Cell,
Wool Felt, Hair Felt, Mineral Wool.

Estimates given and work executed promptly.

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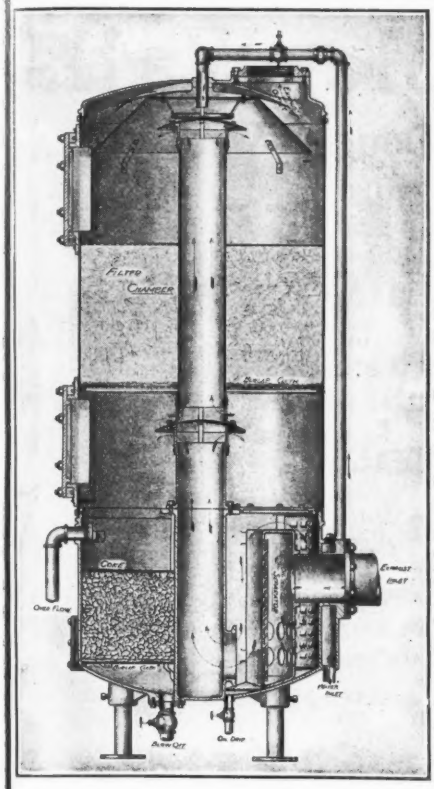
100 N. Moore Street, -:- New York City.

Over 7500 Hammel Oil Burners

In use under Stationary Boilers, Locomotives, Kilns, Etc.

Write for Circular of Hammel Patent Furnace for Water-Tube Boilers

HAMMEL OIL BURNER CO.
609 North Main Street, LOS ANGELES, CAL.



The Massillon Feed Water Heater, Purifier And Oil Extractor

heats the water to the highest possible temperature by breaking it up into small particles and passing it through the steam. It is delivered to the boiler perfectly clean and pure, and all oil is removed from the exhaust by a new method. Send for the details.

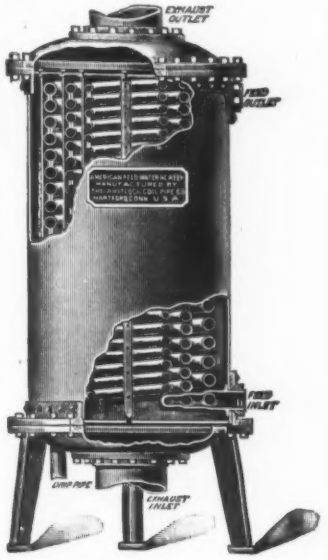
The Russell Engine Co.,
Massillon, Ohio.

The American Standard Copper Coil Feed-Water Heater

represents the highest type of feed-water heating apparatus and should always be used where the highest temperature and most satisfactory results are desired.

It costs no more than less efficient types.

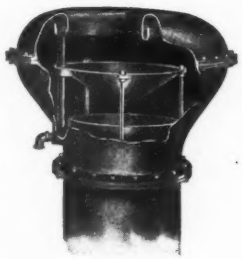
It is the simplest and most widely used type of heater in the market today.



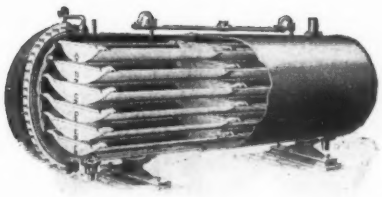
Manufactured by

The Whitlock Coil Pipe Company
Hartford, Conn.
New York Office, Singer Bldg., 85 Liberty St.

HOPPES



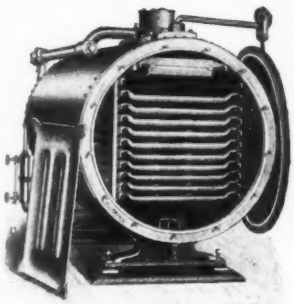
Exhaust Head



Live-Steam Feed-Water Purifier

Oil Eliminator

STEAM SPECIALTIES

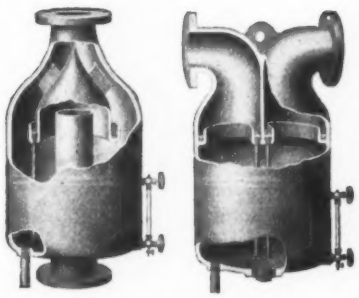


Feed-Water Heater—Class "R"

Exhaust Steam Feed-Water Heaters, Live Steam Feed-Water Purifiers, Steam Separators, Oil Eliminators, and Cast-Iron Exhaust Heads.

Write for Catalog and Prices.

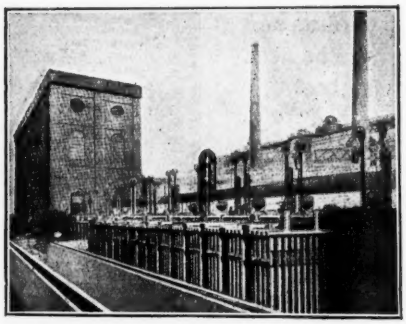
Hoppes Mfg. Co.,
19 Larch Street,
Springfield, - Ohio.



Steam Separators

The

Green Fuel Economizer Stops Smoke



In a recent issue of *Power*, Dr. Lucke, of Columbia University, shows that "it is with the most violently fluctuating loads that the greatest trouble in station operation will be encountered and the greatest difficulty in securing smokeless combustion."

The only way in which sudden demands for steam can be met is by increasing the rate of combustion. This means an increase in the draft. If air enters the furnace faster than the gases are distilled from the fuel, the gases will be chilled and smoke will be formed. If it enters at a slower rate the combustion will be incomplete and there will likewise be smoke. In other words, the rate of combustion cannot be varied suddenly without producing smoke.

The economizer helps to remedy this by holding in reserve a large body of hot water, water upon which from one-fifth to one-fourth of the entire work to be done by the boilers has already been performed. This large body of hot water is sufficient to supply the boilers for a long time, say an hour. Whatever the fluctuations in the demand for steam may be this supply of hot water diminishes their effects upon the fire by 20 to 25 per cent. and helps that much toward preventing smoke.

The economizer also protects the boiler from sudden inrushes of cold water at all times, and especially during periods of heavy driving. It recovers the heat that would otherwise escape the boiler. Increasing the efficiency of the boiler under over-load conditions helps to remedy the smoke evil, for it diminishes the extent of the fluctuations in the rate of combustion. As the boiler efficiency does not fall off so much with high rates of driving, the demands upon the fire are not so extreme.

Let us figure out what the saving would be in your plant. Ask for Catalog 106 P.

The Green Fuel Economizer Co.

MATTEAWAN, N. Y.

New York City, Boston, Chicago, Atlanta, San Francisco, Los Angeles, Seattle, Salt Lake City, Montreal.

Engineers; Builders of Green's Fuel Economizers, Fans, Blowers and Exhausters, Steam Air Heater Coils, Waste Heat Air Heaters, Mechanical Draft, Heating and Ventilating and Drying Apparatus, Draft Dampers and Engines.

130

Double Walls

Like Double Windows

serve as an excellent insulating barrier against radiation losses.

The Baragwanath Steam Jacket Heater

therefore gets the full advantage of every heat unit that it is possible for a feed water heater to extract from exhaust steam.

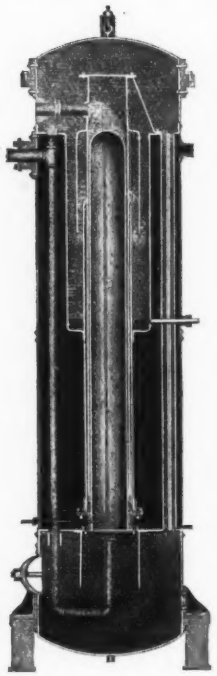
Write

WM. BARAGWANATH & SON,

54 West Division Street,

CHICAGO.

WE MAKE IT TOO HOT FOR SCALE



The Eclipse Feed Water Heater and Purifier, using live steam, heats the water to 300° and thus causes the scale-forming impurities to separate. It gets better results more economically than any other feed water heating device known.

BOOKLET?

The Eclipse Feed Water Heater and Purifier Company,

OSHKOSH, WISCONSIN

Beware Of Scale

But if scale-forming impurities must come, install

The Otis Feed Water Heater and Purifier

and it will make the scale beware of your boiler tubes.

Notice the tilting tube plate, it prevents the sediment from precipitating among the tubes.

THE STEWART HEATER COMPANY,

50 NORFOLK AVENUE, BUFFALO, N. Y.

How To Get Along With Less Fuel

The way is easier than is generally supposed. It simply means installing the Loew Boiler Feed Water Heater, which purifies the feed water and *heats* it to within 2 to 5 degrees of the exhaust steam. Scale is prevented and less fuel is required to generate a given amount of heat.

Every "Tom, Dick and Harry" Heater will not do this. Get the "Loew" and secure *positive results.*

CATALOG?

The Loew Mfg. Co.,

Cleveland, Ohio.

New York Representative, G. L. Todd, 50 Church Street.

There's No Way For Trouble To Get A Start In The

NATIONAL
Feed Water Heater

It has no inside joints or straight tubes to leak. No contact of the water with shell. No back pressure. No freak features. All its parts are positively advantageous. It heats the water to 210-212°. It is high in efficiency—low in price. Over 1,200,000 h. p., now in daily use.

Write for Catalog.

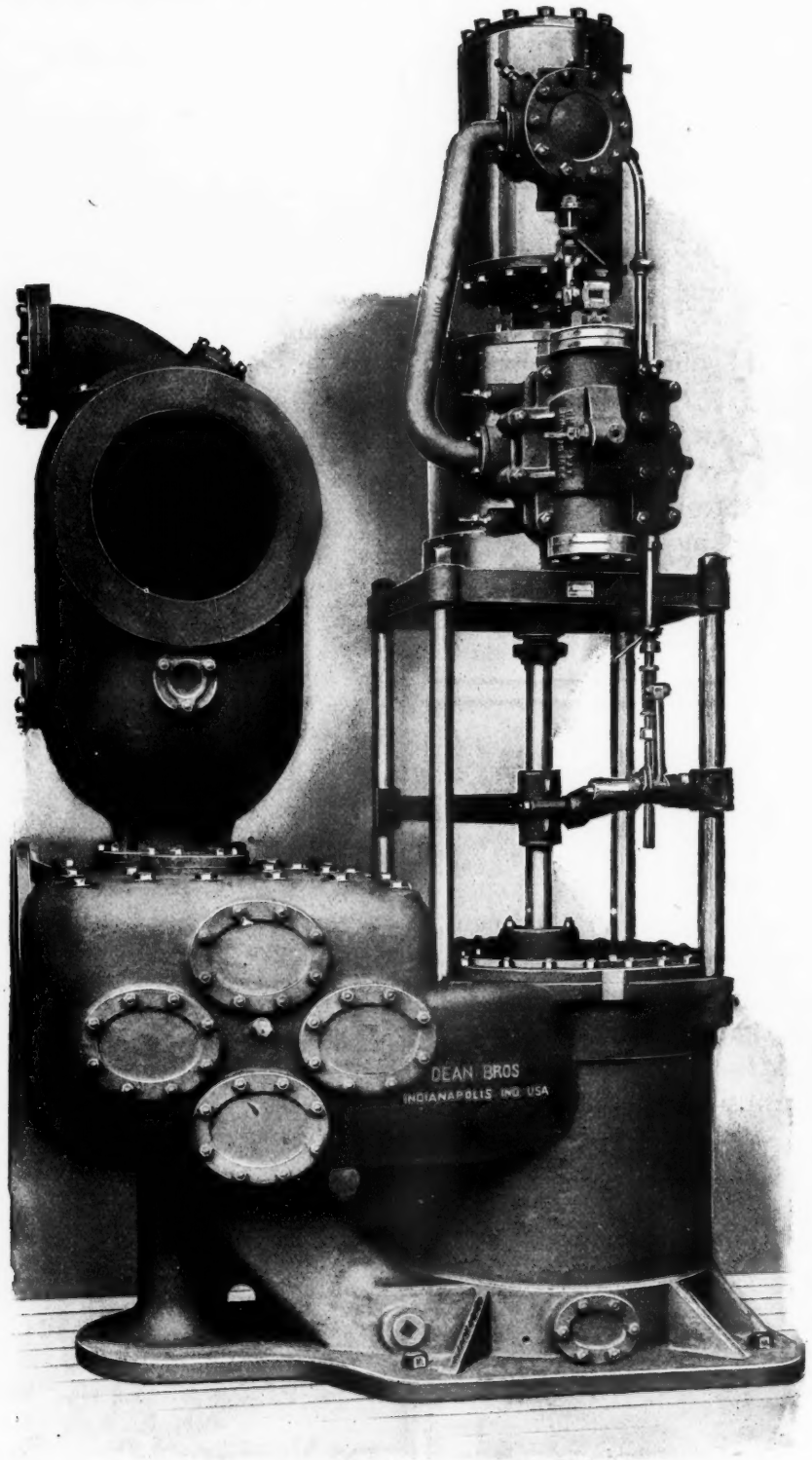
The National Pipe Bending Co.

168 River St., New Haven, Conn.

120 Liberty Street, New York.

54 High Street, Boston, Mass.

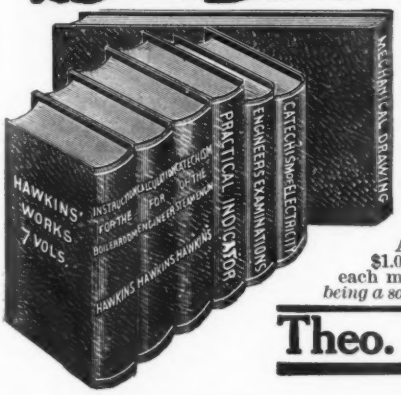
DEAN BROS. STEAM PUMP WORKS
INDIANAPOLIS, IND.



Dean Bros. Vertical Air Pump and Jet Condenser

This air pump is double acting There are no valves in the piston. All valves are quickly accessible through hand holes. The piston rods are separable The cylinder head can be easily removed and taken entirely out of the way, for inspecting interior of cylinder or for repacking the piston. The piston rod stuffing box is provided with a water seal to prevent air from entering. The stroke is instantly adjustable The vacuum is the highest practically attainable.

Hawkins' Works



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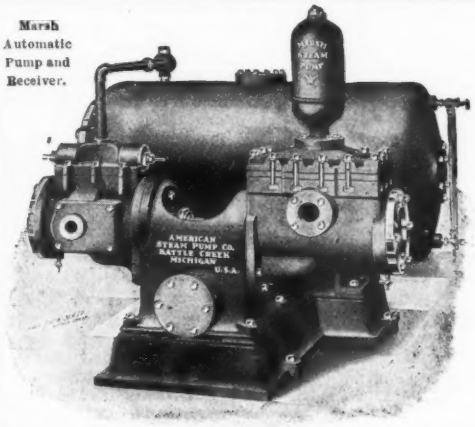
Marsh Automatic Pump and Receiver.



Heating Systems

Simplex not Duplex
To be simple is to be great

are much more efficient when the water of condensation is handled by

MARSH AUTOMATIC PUMPS AND RECEIVERS
or **MARSH VACUUM PUMPS**

Our Catalog 17 G. sent on request.

Steam and Power Pumping Machinery For Every Service

American Steam Pump Co.
Battle Creek, Michigan

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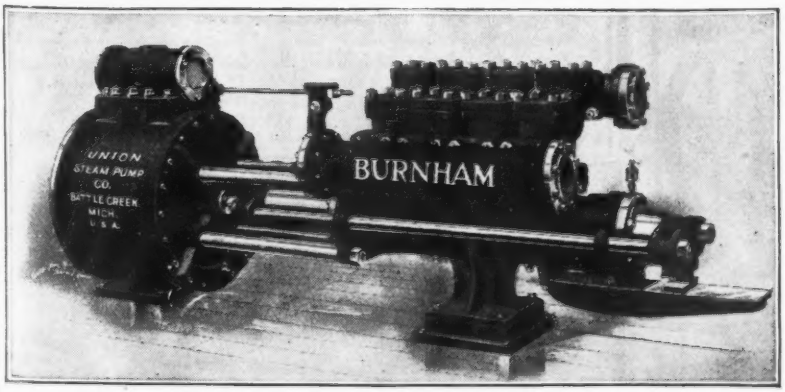
We Make A Centrifugal Pump For Every Use

to which such pumps are adapted. We have been at it for nearly forty years. We make more kinds than any other maker, and we build them in the way that long experience and careful study have shown to be the best way. You know the advantages of Centrifugal Pumps in general; but there are other advantages which we believe are peculiar to our Pumps and we want you to know them.

MORRIS MACHINE WORKS,

New York Office, 39-41 Cortlandt St. BALDWINSVILLE, NEW YORK, U. S. A.

CAMERON & BARKLEY, Agents, Charleston, S. C. and Tampa, Fla.



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GREAT BURNHAM Steam Pumps

WILL NOT SHORT-STROKE

Steam, belt and motor-driven to meet every requirement.

Buy a "Burnham" and Save Money

Made by the

UNION STEAM PUMP CO.

Battle Creek, Mich.

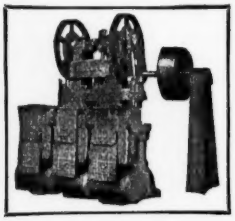
MYERS POWER PUMPS.

Adapted especially for gas engines, motor and belt powers, in harmony with present requirements. Catalog sent on request.

F. E. Myers & Bro.
Ashland, Ohio, U. S. A.

Deming

Ask for Catalogue "G" and treatise "Feeding Boilers."



For any service. **Power**

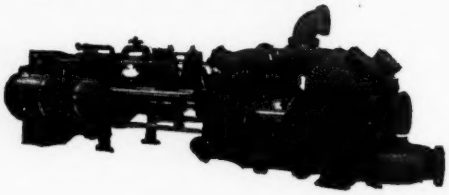
For operation by any power. **Pumps**

The Deming Company
Agencies in Principal Cities **Salem, Ohio**

Warren Steam Pump Co.

Warren, Mass.

PUMPS FOR ALL REQUIREMENTS.



Piston—Plunger—Hydraulic—Deep Well—Power.

Air Pumps and Jet Condensers, Combined Air and Circulating, and Marine. *Catalog.*

The Many Installations of GOULDS Efficient Triplex Power Pumps

For Municipal Water Works
Boiler Feeding
Hydraulic Elevators
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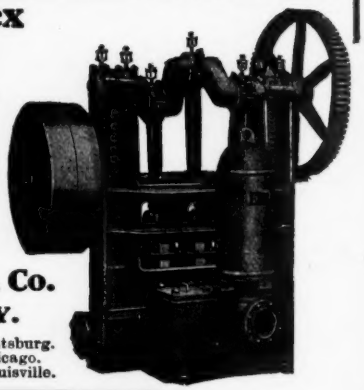
General Water Supply, Etc.

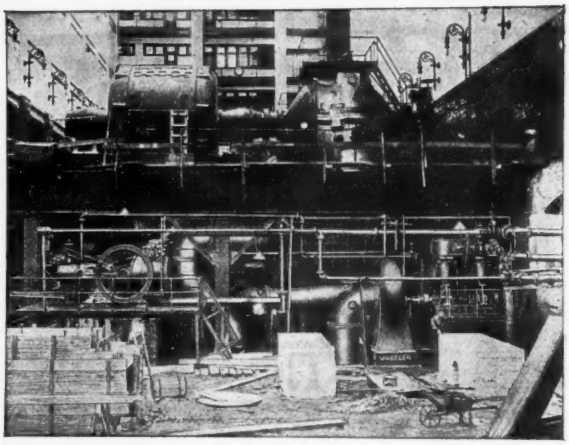
Have fully demonstrated their practicability and efficiency for these important services.



The Goulds Mfg. Co.

Seneca Falls, N. Y.

New York. Philadelphia. Pittsburg.
St. Louis. New Orleans. Chicago.
Los Angeles. San Francisco. Louisville.



WHEELER EQUIPMENT FOR STEAM TURBINES

If you put in steam turbines, provide high vacuum. Much of the superiority of the turbine lies in what it is able to do with the steam below atmospheric pressure. Each inch of vacuum above 26 inches reduces the steam consumption of the turbine by 6 to 10%, in fact, a large exhaust turbine will take the steam from a compound engine at atmospheric pressure and make nearly as much power out of it as the engine has made in bringing it down from 120 gauge to atmosphere.

It goes without saying, then, that where turbines are put in the best condensing equipment obtainable is installed. We show such a plant above. The steam turbine has a capacity of 15,000 H.P., and exhausts into a Wheeler Surface Condenser operated in connection with a Wheeler Dry Vacuum Pump, and a Wheeler Circulating Pump driven by a Wheeler Vertical Engine

There are four more Wheeler outfits like this in the same power station. We could give you plenty of similar examples. In some cases Wheeler Jet Condensers and in others Wheeler Barometric Condensers are used, and in many places, perhaps the majority, a Wheeler-Edwards Air Pump produces the vacuum, displacing both the dry-vacuum pump and hot-well pump.

The first successful steam turbines of American invention were equipped with Wheeler condensing apparatus, and the latest and largest yet built depend on Wheeler apparatus for their high efficiency.

If you are thinking of putting in a steam turbine, therefore, or, in fact, if there is a possibility of running condensing in any case, write to us for suggestions and estimate.

By the way, are you on our mailing list for the series of Treatises on Condensing Machinery which we are now publishing? When writing kindly mention this paper.

We build Wheeler Surface, Jet and Barometric Condensers, Wheeler-Volz Combined Surface Condensers and Feed Water Heater, Wheeler Feed Water Heaters, Barnard-Wheeler Cooling Towers, Wheeler-Edwards Air Pumps, Wheeler Centrifugal Pumps, Wheeler Rotative Dry Vacuum Pumps and Wheeler Multiple Effect and Evaporating Machinery.

WHEELER
CONDENSER & ENGINEERING CO.
CARTERET, NEW JERSEY.

Alberger Barometric Condenser

ALBERGER

Complete Condensing Equipments

SURFACE — High Efficiency

CENTRIFUGAL — Internal Air Cooling

BAROMETRIC — High Vacuum

DRY VACUUM PUMPS with Alberger Condensers give highest vacuum

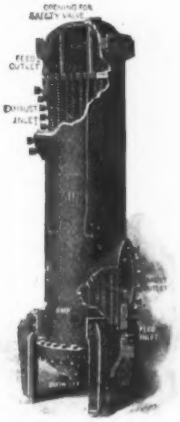
COOLING TOWERS regulated and sub-divided air supply. Perfect water distribution.

WAINWRIGHT HEATERS

Even flow Feed Water Heaters. Distilling Condensers. Hot Water Service Heaters.

High Water Velocity through Straight Corrugated Copper Tubes. Large Capacity. Small Size.

CORRUGATED COPPER EXPANSION JOINTS.



Wainwright Feed Water Heater

ALBERGER CONDENSER COMPANY,

95 LIBERTY ST., NEW YORK, N. Y.

Reeves & Skinner Machinery Company.
617 Chemical Bldg., St. Louis, Mo.

BRANCH OFFICE:
205 La Salle St., Chicago, Ill.

COOLING TOWERS

Fan—and Natural Draft

GEORGE J. STOCKER

St. Louis, Mo.

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Guaranteed to form the best Vacuum by head of water or by supply pump

The Bulkley Injector Condenser

In general use on all classes of engines.

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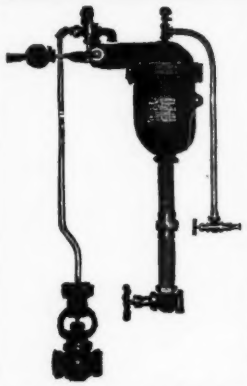

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Constructed on a different and better principle than any other.

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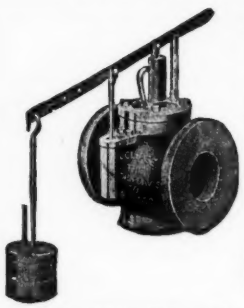

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is the one you want for reducing or regulating steam from any initial pressure to a lower pressure where the flow is constant.

It is the most simple valve on the market. No spring. No diaphram. No stuffing box.

The Oldest Valve of Its Kind. Absolutely Dependable

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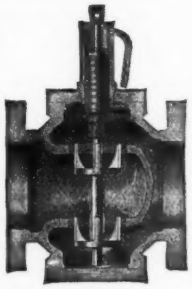

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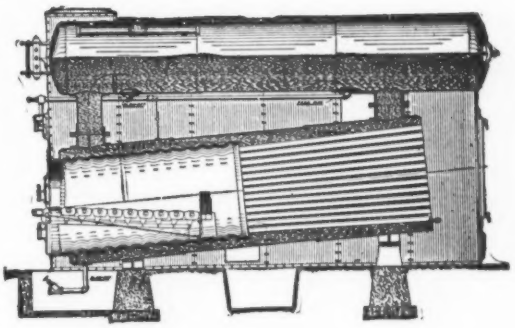

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For maintaining an even water pressure. Should be used on all steam pumps where a fixed discharge pressure is desired. Designed right and made right, it is automatic and reliable. Send for catalogue.

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The Automatic Stop Of The GARDNER GOVERNOR

closes the valve the instant a belt breaks or other accident occurs—by removing the speed lever fulcrum. Its action is guaranteed reliable. Write.

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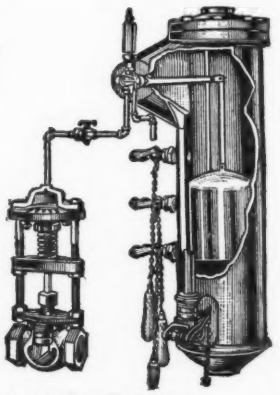
Safety Automatic

Feed Water REGULATOR



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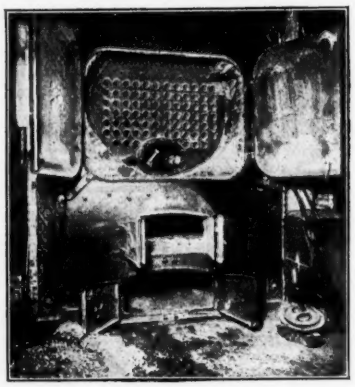

Boiler inspector inside boiler "hammer-testing" the sheets

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The Company grants insurances as follows:

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In the Fidelity, Boiler, Elevator, and Fly-Wheel lines careful inspections are made by experts.

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Our aim is prevention of explosions. But when these do occur, and they will occur through unavoidable causes, indemnity is provided for 1st, the direct loss of property; 2nd, damages for property of others destroyed; and 3rd, damages for personal injuries.

Write to us for rates and particulars.

Boiler inspector testing steam gauge

MORRIN CLIMAX BOILERS

They supply perfectly dry steam superheated to over 80°, and hold full pressure under all conditions. They produce more steam per pound of coal than any others on the market. Made in all sizes from 50 to 1000 H.P. CATALOG ?

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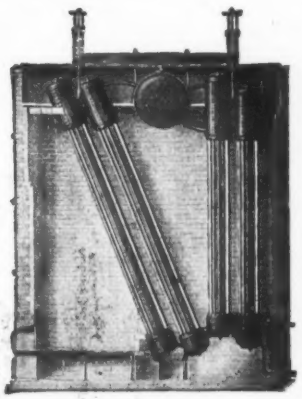
The Bigelow-Hornsby Water Tube Boiler



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ALL PARTS, BOTH EXTERNAL AND INTERNAL, READILY ACCESSIBLE.
ALL BOILER TUBES PERFECTLY STRAIGHT.

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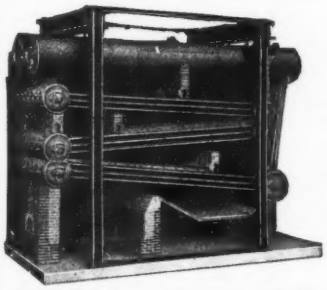
Our Boilers Make Less Scale



than boilers of any other make because they circulate the water more rapidly, heat it more uniformly and cause impurities to settle in the mud drum while the water is yet cool.

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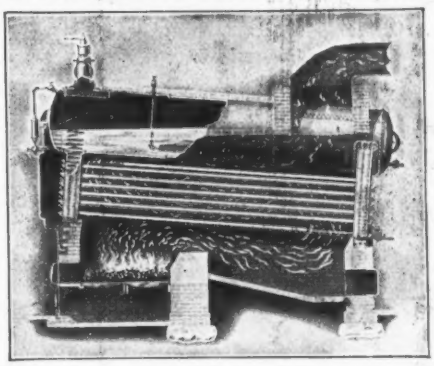
FRANKLIN WATER TUBE BOILER



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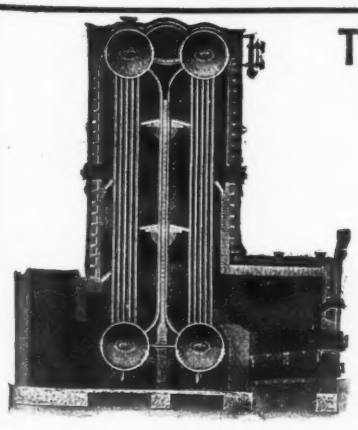
THE RUST WATER TUBE BOILER



Type B

Safe
Simple
Economical
Durable
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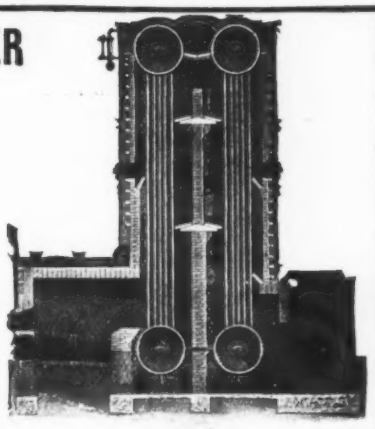

Type O

TUBULAR AND WATER TUBE TYPES

TUDOR BOILERS

INCORPORATED 1834

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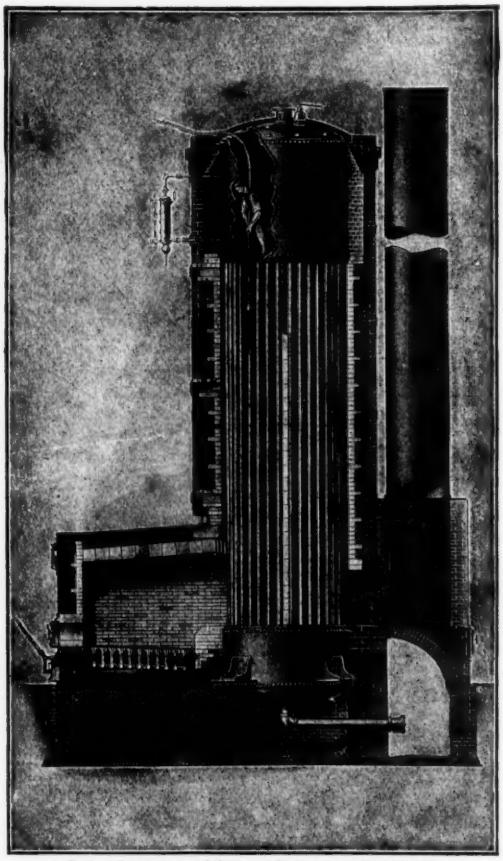
The Wickes Boiler

Vertical Water Tube

Ever cleaned a boiler? Know how hard it is? If you have you will appreciate this boiler at a glance.



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Two 12″ x 16″ manholes open the Wickes Vertical Water Tube Safety Steam Boiler from top to bottom for inspection and cleaning. Every tube can be looked through; every tube washed or scraped.

Safe.

Low cost of maintenance.

High furnace and heat abstracting efficiency.

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HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO. HARTFORD, CONN.

1866 1908

FORTY-FIRST ANNUAL STATEMENT.

JANUARY 1st, 1908.

Capital	$1,000,000.00
Surplus	1,006,868.06
Reserves	2,053,326.74
Assets	4,060,194.80

The HARTFORD was the PIONEER Company in the field of steam boiler insurance and it is the only company which makes a specialty of and does exclusively a steam boiler inspection and insurance business.

The HARTFORD is the only Company whose entire talent and energy are applied to the study of steam, to the scientific construction and installation of boilers and to their periodical inspection by expert mechanics.

The HARTFORD is now doing nearly 1/10 of the inspection and insurance of steam boilers in the New England States, and nearly 1/5 of the entire amount done throughout the United States.

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will reinforce the ends of your tubes—where they become weak—and make the old ones as good as new. There's money in it. Particulars?

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All Flange Steel Construction

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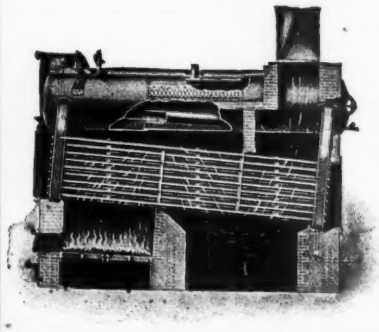

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POSITIVE VENTILATION
IS SECURED BY
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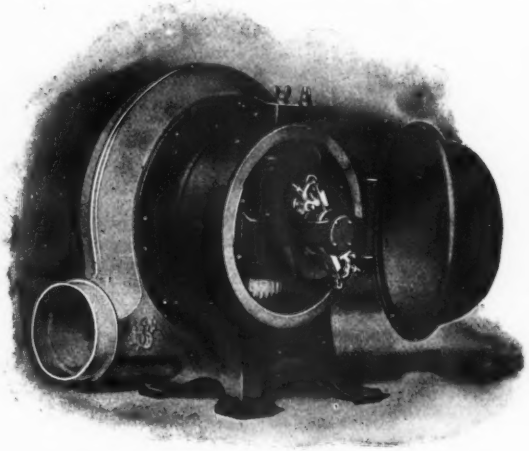

They can be placed just where wanted with regulating rheostat in a convenient location. Motors are of enclosed dust-proof type or semi-enclosed.

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One 50 H. P. Tandem Cylinder Gas Engine little used, at a bargain. Also 3 or 4—25, and 30 H. P. Gas Engines at a reduced price. Good as new.

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Increase capacity of boilers, give more power with less fuel, and prevent all loss and trouble due to wet steam.

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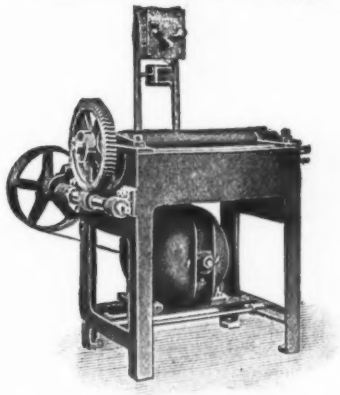
For Service

Let us send you our booklet "The Way to Forget"



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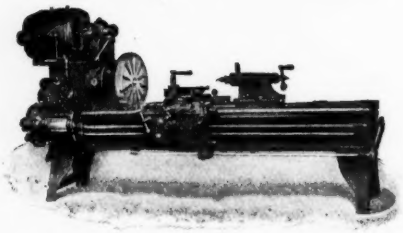
General Electric Company

Did you ever know of a shop going back to belts after using

General Electric Individual Motor Drive?



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Everywhere through the woodworking shop, the machine shop, the forge shop and the foundry, GENERAL ELECTRIC MOTORS are replacing belt drive.

There is no operation too small, no task too difficult to be satisfactorily and economically performed with a separate motor for each machine.

Lathes	Saws
Drills	Planers
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are a few of the machines commonly driven by

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If you are using belt drive it will pay you to investigate.

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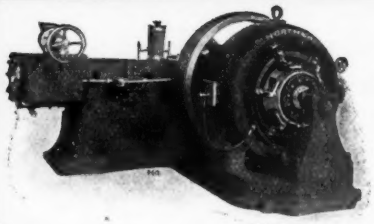

Northern Generator direct connected to Bayley Engine.

THE LATEST PRACTICE IN GENERATOR DESIGN

Is embodied in the new Northern Type "L" Generator for direct connection to engines. The trisected laminated poles, affording perfect commutation, and the natural system of ventilation, insuring low temperature rise, used in the Type "L" design are points worthy of your investigation.

Send for Bulletin 3355. The amount of practical generator information contained in this Bulletin will surprise you.

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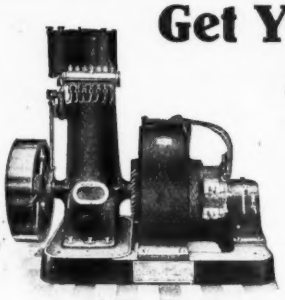

Wherever there's a boiler the Engberg Generating Set will furnish current for steady lights much more cheaply than you can buy it from the public mains. Let us send you descriptive circular.

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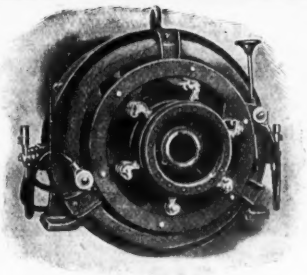
St. Joseph, Michigan



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C&C

GENERATORS AND MOTORS

having nearly 25% more ventilating area than other machines, are the coolest running. They are also furnished with the reaction type of brush holder—the best on the market. Get our catalogue.

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Otto Suction Gas Producers and

OTTO ENGINES are reliable and can be operated by men of ordinary intelligence.

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This man, without special instructions but with the use of "horse sense" causes his plant to work fine. There is a volume of praise for "OTTO" machinery in Mr. Witter's short letter.

OTTO OTTO

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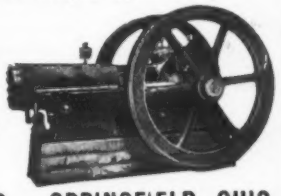
FOOS GAS AND GASOLINE ENGINES

HAVE WIPE SPARK IGNITER, positive acting and self cleaning.

VERTICAL VALVES, mechanically operated, admit fuel charge into cylinder at atmospheric pressure.

CENTER-LINE COUNTERBALANCING increases the efficiency and decreases the fuel bills.

ACCESSIBLE DESIGN makes it a simple matter to keep Foos Engines properly adjusted.



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THE FOOS GAS ENGINE CO., SPRINGFIELD, OHIO.

PRODUCER GAS

THE CHEAPEST POWER IN THE WORLD

GAS ENGINES, GAS PRODUCERS
COMPLETE PLANTS INSTALLED

BROOMELL, SCHMIDT & STEACY CO.,
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GAS PRODUCERS

FOR

POWER AND FUEL GAS;

COAL GAS & WATER GAS APPARATUS.

THE GAS MACHINERY CO.,
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OVERCOME YOUR ALIGNMENT TROUBLES!

USE B-M-A
FLEXIBLE LINK COUPLING

The ideal method for connecting prime movers to

GENERATORS, BLOWERS, COMPRESSORS, PUMPS, ETC.

Standard sizes up to 500 H.P., but we design them to meet all conditions and will be pleased to learn of yours.

THE BRUCE-MERIAM-ABBOTT CO.,
1688-1692 Columbus Road,
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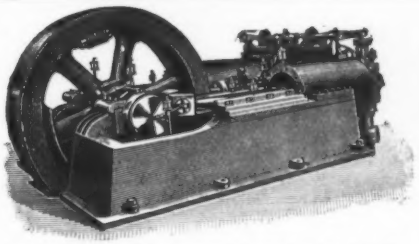
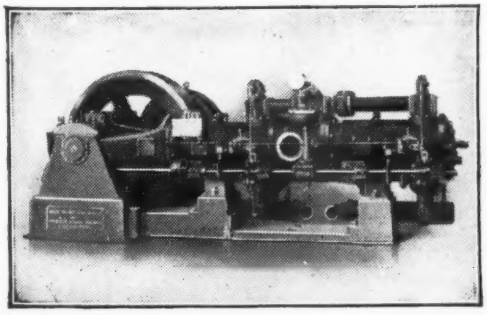
The Miller Gas Engine



is the result of ten years of practical experience in the design of gas engines for heavy duty. It is built in 35, 50, 75, 100, 150 and 250 H.P. sizes. Among its unusual features is our patented system of vacuum governing, which gives a regulation only equaled by the steam engines. The many other good points of this most economical source of power are fully described in the catalog, which is sent on request.

THE MILLER IMPROVED GAS ENGINE CO.,
Springfield, Ohio, U. S. A.



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deliver more power for the fuel they consume than any other engines made. They use natural or city gas, gasoline or producer gas.

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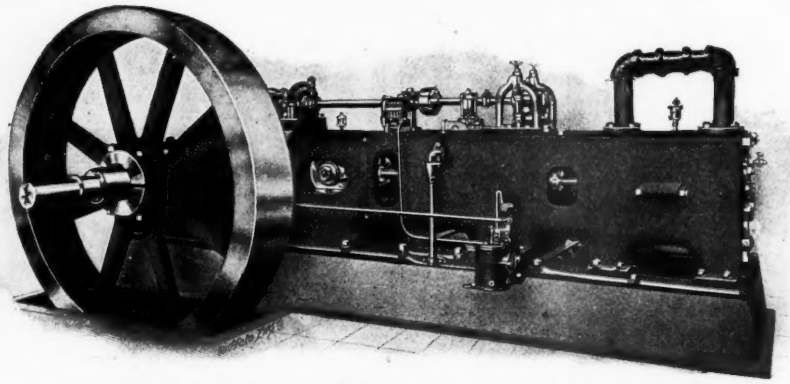
DUBOIS IRON WORKS,
ESTABLISHED 1877.
805 Brady Street, DUBOIS, PA.



Riverside Heavy Duty Gas Driven Air or Gas Compressor. (Class A.)

Not Made From Wash Drawings

The cuts we show are made from engines we have built and delivered to purchaser, and they are giving steam engine satisfaction at a fraction of the cost, some of them in twenty-four hours' service. The RIVERSIDE heavy duty gas engine, is wholly unlike any other and is built in twelve types and seventy-two sizes from 10 to 2500 H. P.

We also Build a Complete Line of Gas Driven Air and Gas Compressors

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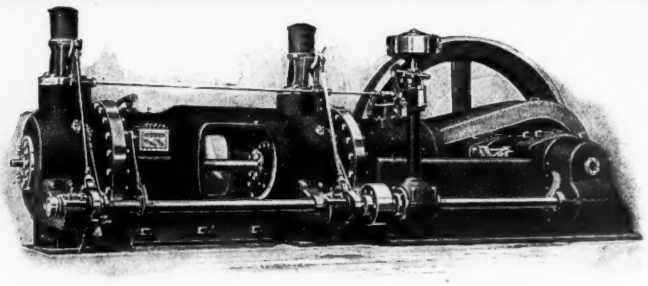

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AND
SUCTION GAS PRODUCERS

SATISFACTORY AND CONTINUOUS SERVICE
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FEW IN NUMBER
EASY OF ACCESS

ENGINES OF VERTICAL AND HORIZONTAL TYPES
75,000 HORSE POWER IN SUCCESSFUL OPERATION
STRUTHERS-WELLS COMPANY, - - - Warren, Penna.

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FUEL
GAS, GASOLENE, KEROSENE, ALCOHOL
STATIONARY AND MARINE
ALL PURPOSES TEN TYPES ALL SIZES

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416 Broome Street **New York City**

ENGINE AND BOILER BARGAINS

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20 x 42 Allis, Corliss	16 x 32 Buckeye, Automatic
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Also large assortment of Automatic and Throttling Engines of other sizes.

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84 x 18, 78 x 16, 72 x 18 High Pressure, 72 x 16, 66 x 16 and smaller sizes of Horizontal Tubular Boilers, also Vertical and Fire Box Boilers from 5 to 60 H. P.

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We are the sole manufacturers of the celebrated "Leader" Injectors and Jet Pumps.

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WE MAKE A SPECIALTY OF

Corliss Engine Repairs. Engines Indicated.
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Pumps, etc., all kinds Special Machinery.
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We Manufacture
AN ECONOMICAL AND DURABLE ROTARY ENGINE
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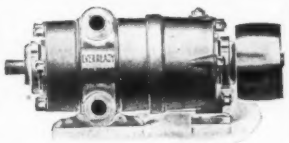

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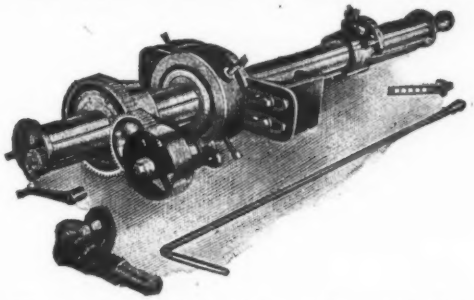
316 HUDSON ST., NEW YORK CITY and 159 GREEN ST., BOSTON.



You'll save unlimited time and money by reboring your own cylinders with our Portable Bar.

HUGH MATHEWS, KANSAS CITY, MO., U.S.A.

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Denatured Alcohol from Natural Gas.

Plans, specifications, estimates and supervision for

Continuous Industrial Alcohol Distillery Apparatus,

for light, heat and power purposes from natural gas and Portable Stills for vegetable waste matter. Economy and rapidity of construction a specialty. Unquestionable references.

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See Harper's Weekly, Oct. 3, 1908. Patent Serial No. 450,294—Aug. 25

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Bearing Metal

Stays Where It's Put And Is Frictionless

It has a new efficiency for all factory and machinery bearings and its lasting power is remarkable. Sells for 25c a pound at all dealers, or direct from us in 50-lb. trial boxes. Try it.

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ALBERGER TANDEM GAS ENGINES

ACCURATE REGULATION FOR ELECTRIC SERVICE-AUTOMATIC CUT-OFF AND RITES FLY-WHEEL GOVERNOR

A.H.ALBERGER COMPANY

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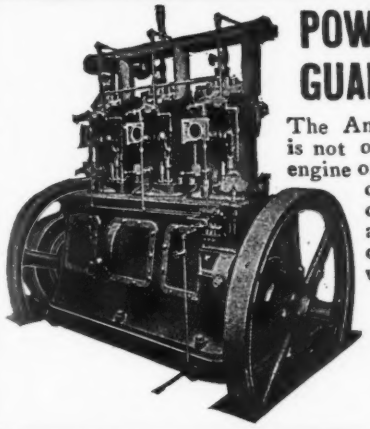

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The American Diesel Engine is not only the most efficient engine on earth but it burns the cheapest liquid fuel—crude oil. We can guarantee a cost which no other engine can develop under test.

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They don't send me out with every engine they sell, because strictly speaking I'm not a Mechanical Engineer. I hear a lot of engine talk, tho, for the State of Wisconsin builds more Corliss Engines than any other four states. I know something about "higher speed" Corliss Engines and "COMPLETE EXPANSION" Gas Engines and I'll tip you off next week.

Wisconsin Engine Co.,
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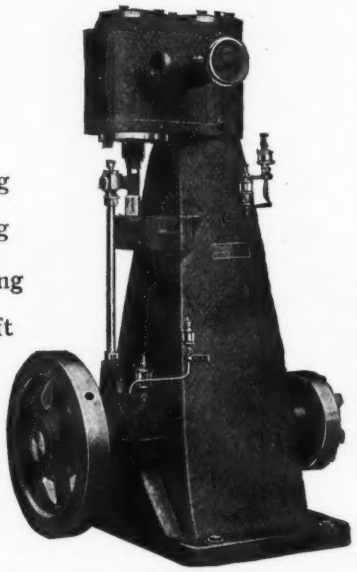
Marine Type
Type "O"
Single Double Acting
Double Single Acting
Double Double Acting
Cylinder Below Shaft



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BALLWOOD ENGINES

are slightly higher in cost, but this is *more than justified* by their wonderful economy, efficiency and durability. No other "prime movers" possess Ballwood Quality. We build

Single Valve

Center Crank, Automatic Cut-off Engines, single cylinder and compound;

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Non-releasing Gear Engines, both vertical and horizontal — simple and compound.

Also Welded Flanged Pipe And Bends

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New York Sales Office, Cortlandt Building, 30 Church Street.

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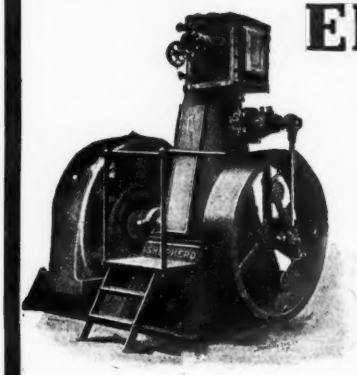

There's an old saying: *"The best is always the cheapest;"* and your own experience has proved it true a hundred times.

The tailor-made suit costs more than the "hand-me-down" but it lasts so much longer and feels so much better that it's cheapest in the end.

It's just so with SHEPHERD Engines. They cost a little more at first, but every extra dollar means *quality*.

Not frills or fancy trimmings, but perfect balance, close regulation, fine material, and lots of it where needed. Every possible effort, in fact, of skilled and honest workmanship toward the perfect engine. That's why "They're cheapest in the end."

Write for catalog and particulars.

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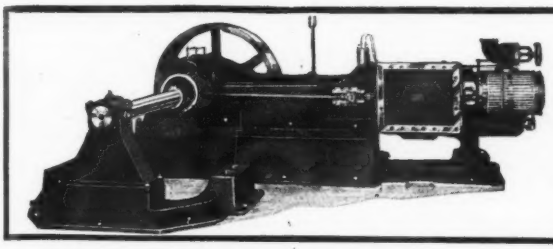

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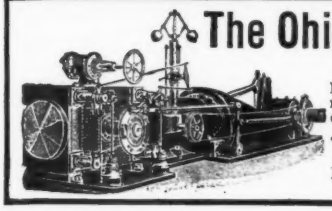
have set a new mark for maintained economy, close regulation and perfection of lubrication.

SKINNER ENGINE CO., - ERIE, PA.



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For hard work, heavy loads and high-speed, the Ohio shows close regulation and runs smoothly and quietly.

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Simple, condensing and compound, 50 H. P. to 2000 H. P. Complete steam power outfits for every service, Superior in workmanship and performance.

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Write for bulletin describing our direct connected units.

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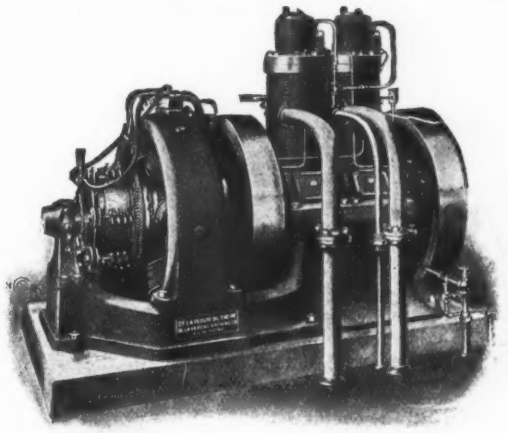

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OIL ENGINES

are cheaper, simpler. more compact than any other motive power. 8 H. P. hours per gallon of cheap oil.

5315 H.P. used by Baldwin Locomotive Works

The "De La Vergne" Vertical two-Cycle 4 to 25 H. P.
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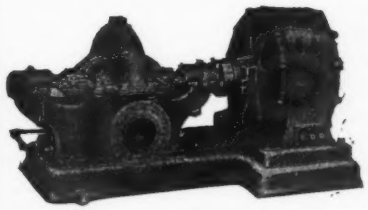

De Laval A. C. Motor-Driven Pump.

Steam Turbine Motors
Steam Turbine Dynamos
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Steam Turbine Centrifugal Pumps
Electric-Motor Centrifugal Pumps

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DE LAVAL STEAM TURBINE CO., Trenton, N.J.

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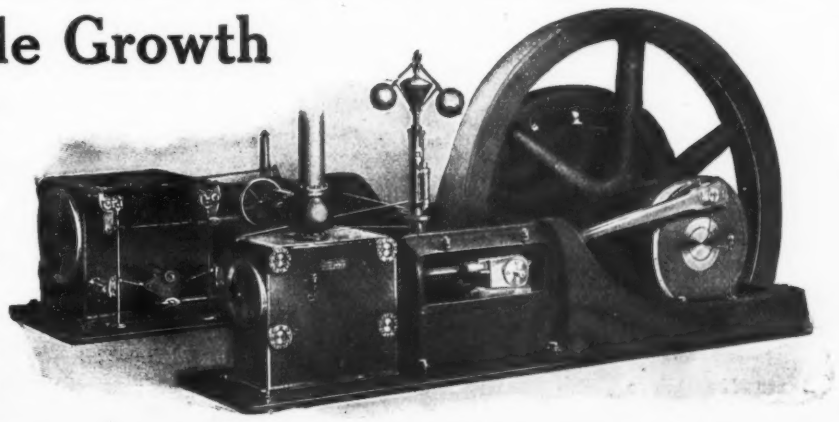

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Mt. Vernon, Ohio.

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New York, 918 Bowling Green Bldg.; Boston, 411 Weld Bldg.; Pittsburg, 604 Frick Bldg.; Philadelphia, Drexel Bldg.; Atlanta, 310 Candler Bldg.; Charlotte, N. C., Court House Square; Chicago, 1539 First Nat'l Bank Building.

The Engine For Hotels, Office Buildings And Hospitals.

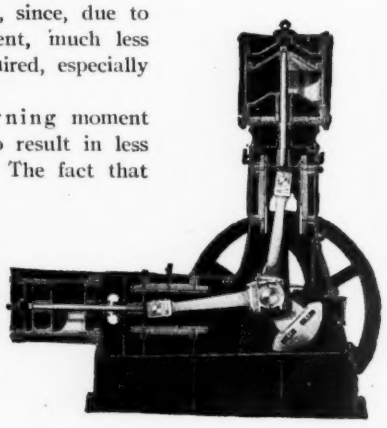
SUPPOSE a giant were to bounce a two- or three-ton rubber ball up and down in the basement of your building at a rate of 250 times a minute. Would you notice any vibration on the upper floors? A similar thing occurs when you install, say, a single-cylinder 160-H.P. electric-light engine and run it at the same speed.

The best that can be done to balance a single-cylinder engine is but a poor compromise. With no counterweight there is a powerful tendency to shift the engine to and fro upon the foundations. If the reciprocating parts are completely balanced, equal unbalanced forces are created in a vertical direction that have an effect upon the engine foundations similar to that produced by the bounding of the two-ton rubber ball. The engine designer usually takes the middle course—that is, puts on a counterweight about half heavy enough to counterbalance the reciprocating parts, so that instead of a two-ton rubber ball you have a one-ton ball.

We offer you an engine that has no unbalanced forces whatever, that can in fact be set upon a light foundation, such as second-story concrete floors, without bolting down, and can then be run at full speed without producing the least tremor.

Such an engine is the **American-Ball Angle Compound,** which has two cylinders set at right-angles so that the resultant of the forces produced by the reciprocating parts can be exactly balanced in all positions by a single counterbalance. This arrangement results furthermore in a marked saving of room. There is likewise a saving in weight, since, due to the even turning moment, much less flywheel capacity is required, especially for driving alternators.

The more even turning moment and lighter flywheel also result in less wear on the bearings. The fact that the engine is compounded reduces the steam consumption by 25 per cent. as compared with a single-cylinder engine.



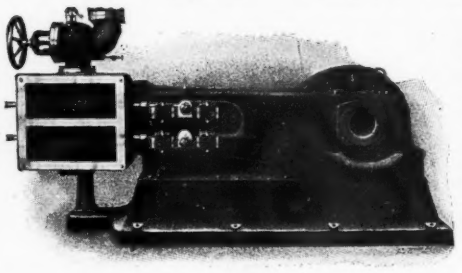
Before finishing the plans of your engine room get Bulletin No. 14

The American Engine Co.

22 Raritan Ave., Bound Brook, N. J.

11

Chuse Four Valve Engine



The best possible combination of economy and simplicity for the high rotative speeds of standard generators. 50 to 300 K. W.

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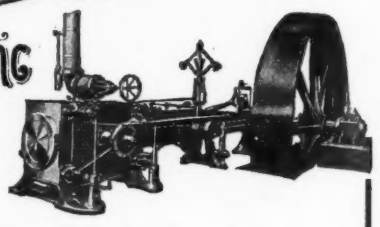
Chuse Engine & Mfg. Company
MATTOON, ILL.

THE IMPROVED FISHKILL CORLISS ENGINE

BUILT BY THE FISHKILL LANDING MACHINE CO., FISHKILL ON THE HUDSON N.Y.



The most efficient and economical power for all purposes.

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CORLISS
AND
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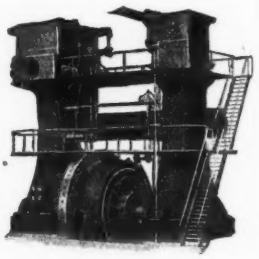

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Complete Power Plants.
THE VILTER MANUFACTURING COMPANY,
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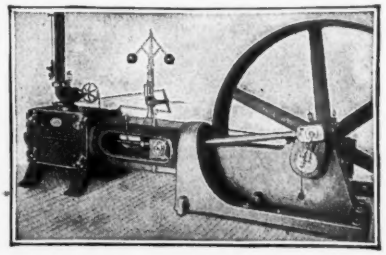

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ICE MACHINES

Close Regulation of Speed
Least Conduction of Heat
Small Clearances
Free Steam Openings
and Free Exhaust.

Write today for Catalog 61.

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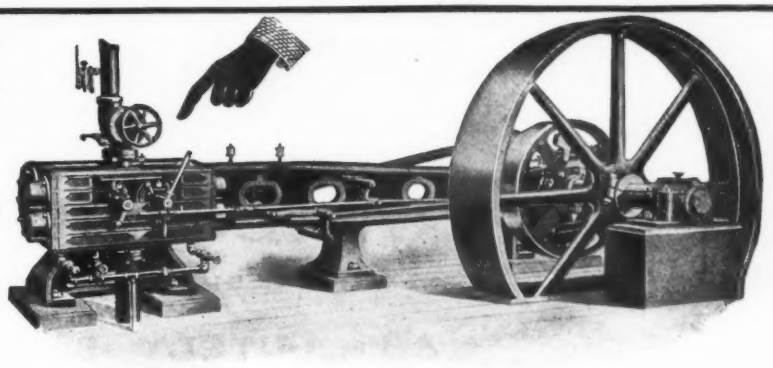
Fitchburg, Mass.



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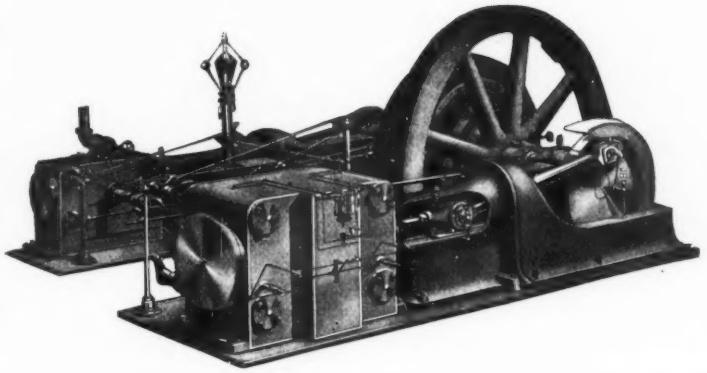

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NEWARK, N. J.

IMPROVED PATENT DOUBLE PORT CORLISS ENGINES

SIMPLE, TANDEM AND CROSS-COMPOUND CONDENSING AND NON-CONDENSING

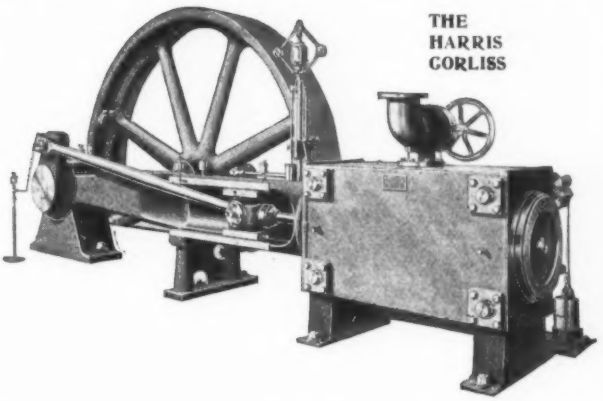
HEAVY DUTY OR GIRDER FRAME

COMPLETE MOTIVE POWER PLANTS A SPECIALTY

Two "Sample" Features
OF THE
Harris-Corliss Engine

The Brown Patented Releasing Gear, which is the simplest and best ever applied to an engine. The Porter Regulator, which has heavy balls and counterweight, giving great power and sensitiveness at high speed. Write for others.

WM. A. HARRIS STEAM ENGINE CO.,
PROVIDENCE, R. I.



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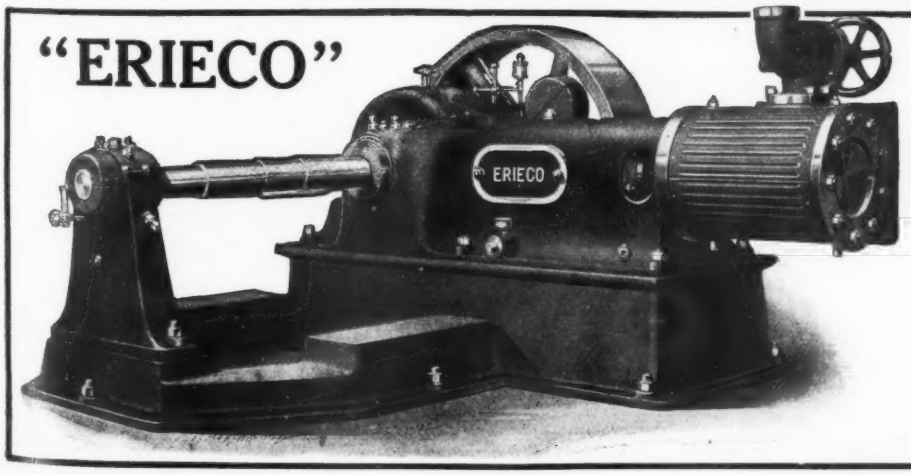

These engines operate smoothly and noiselessly, without excessive heating—and this goes for severe continuous service.

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Erie Mfg. & Supply Co.,
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BUCKEYE ENGINE COMPANY,

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BUILDERS OF HIGH CLASS

STEAM AND GAS ENGINES

HIGH IN DUTY, SUPERIOR IN REGULATION

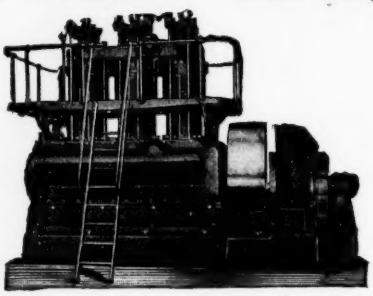
AND

ABSOLUTELY RELIABLE

CORRESPOND WITH US BEFORE PURCHASING

CATALOGS ON APPLICATION

The "Rathbun" Gas Engine



We contract power plants complete;- including producers designed for Anthracite and Bituminous Coals or Lignite, or engines for Natural or Illuminating Gas.

Elements of Highest Quality

Reliability

- The main bearings are generously lined with genuine babbitt and are adjustable or removable without disturbing any other part of the engine.
- The crank shafts are of nickel steel.
- The exhaust valves and cages are water cooled and the valve stems are equipped with sleeves which eliminate corrosive wear from exhaust gas.

Economy

- The plan of circulation insures water of lower temperature in valves and head than in cylinder.
- The combustion chamber has the minimum radiating surfaces.
- The ignition point is automatically controlled by the governor.

Multiple operation of direct connected alternators guaranteed.

THE RATHBUN-JONES ENGINEERING CO.
835 SPENCER STREET TOLEDO, OHIO

FLEMING-HARRISBURG ENGINES

are known the world over for their satisfactory and economical operation in all kinds of diversified service—built

Simple, Tandem and Cross Compound
in both **Single and 4-Valve Types**

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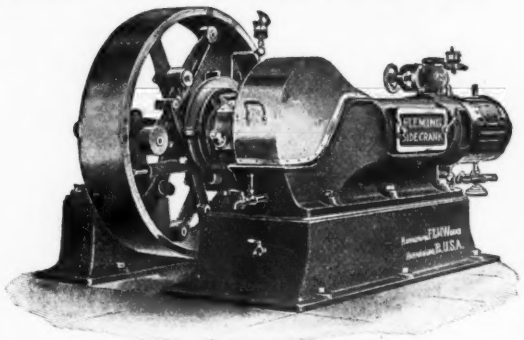
Harrisburg, Pa., U. S. A.

Selling Offices in all principal cities.



McINTOSH, SEYMOUR & CO., Auburn, N. Y.

ENGINES

VERTICAL, HORIZONTAL.

BELTED, DIRECT COUPLED.

Simple, Compound. Triple Expansion.

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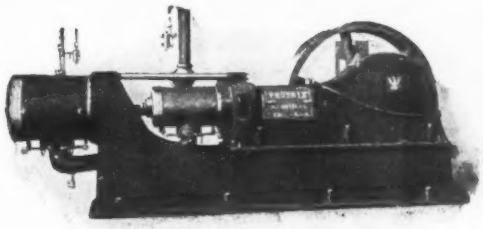
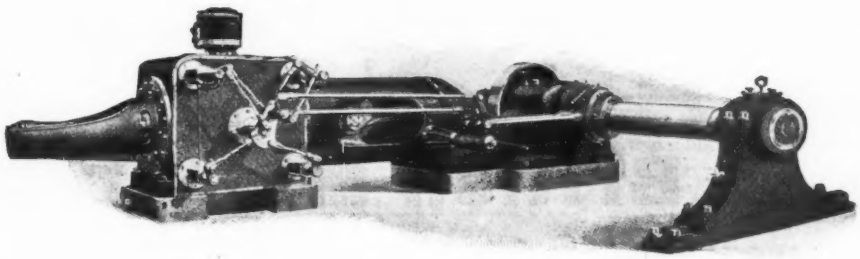


General Offices and Works: - - MEADVILLE, PA.

THE CLARK HEAVY DUTY CORLISS ENGINE



Valve travel never varies. No other Corliss engine has this advantage. Result perfect valve seats. Cuts off at all loads. As quick as the releasing gear. Heavy duty bed with bored guide. Main bearings half diameter of pistons. Length in proportion. Outboard bearing pedestal type. Adjustable in all directions. And self-oiling. Shaft swelled between bearings. Wheels above ten feet in diameter in halves. All wheels have split hubs. Our engines are unequaled for low steam consumption, perfect regulation, long life, nominal repairs, beauty of design. Perfect distribution of metal, high class material. Perfect workmanship.

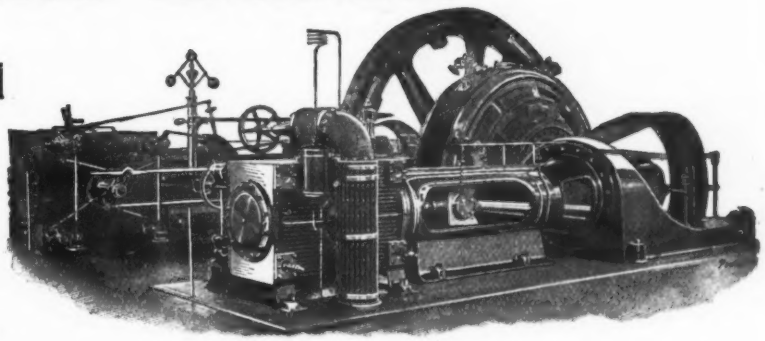
THE CLARK BROS. CO., - Belmont, N. Y.

CORLISS ENGINES.

Simple, Tandem and Cross Compound

From 50 to 3000 H. P.

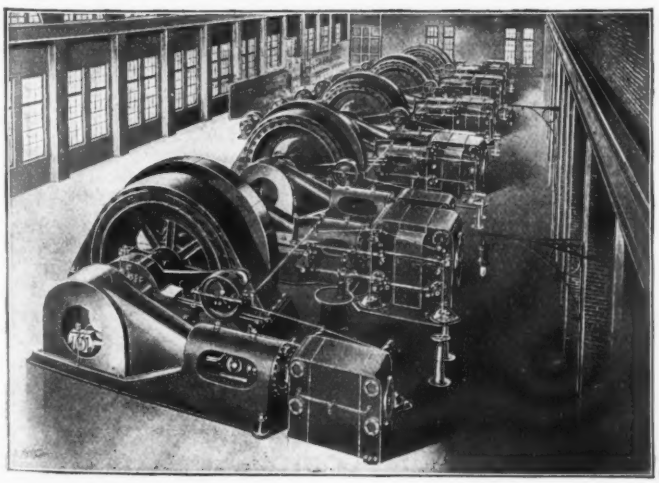
Heavy Duty or Girder Frame.



ST. LOUIS IRON and MACHINE WORKS,

Main Office and Works, St. Louis, Mo.

New York Office, 135 Broadway.



Rice & Sargent Corliss Engines

ARE NOTED FOR

Reliability, Economy, Overload Capacity and Speeds Higher than Other Corliss Types.

RESULT—Lowest Final Cost of Power

The illustration shows RICE & SARGENT engines operating Alternating Current Generators in Parallel at 100 R.P.M.

The maximum capacity of the plant shown is 12000 H.P.

DESIGNED AND BUILT BY

PROVIDENCE ENGINEERING WORKS

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STEAM ENGINES

George H. Corliss. **Greene-Wheelock.**

DIESEL ENGINES

Sole Builders For American Diesel Engine Co.

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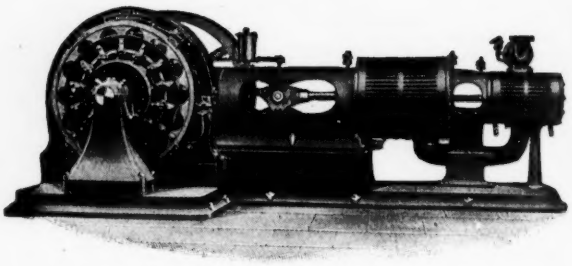
The Best Dynamo Driver And The Best Dynamo Driven



Ridgway Engines and Generators run together with such perfect balance, speed and regulation that they have no near rivals in economic electric generation. Full details on request.

Ridgway Dynamo & Engine Co.,
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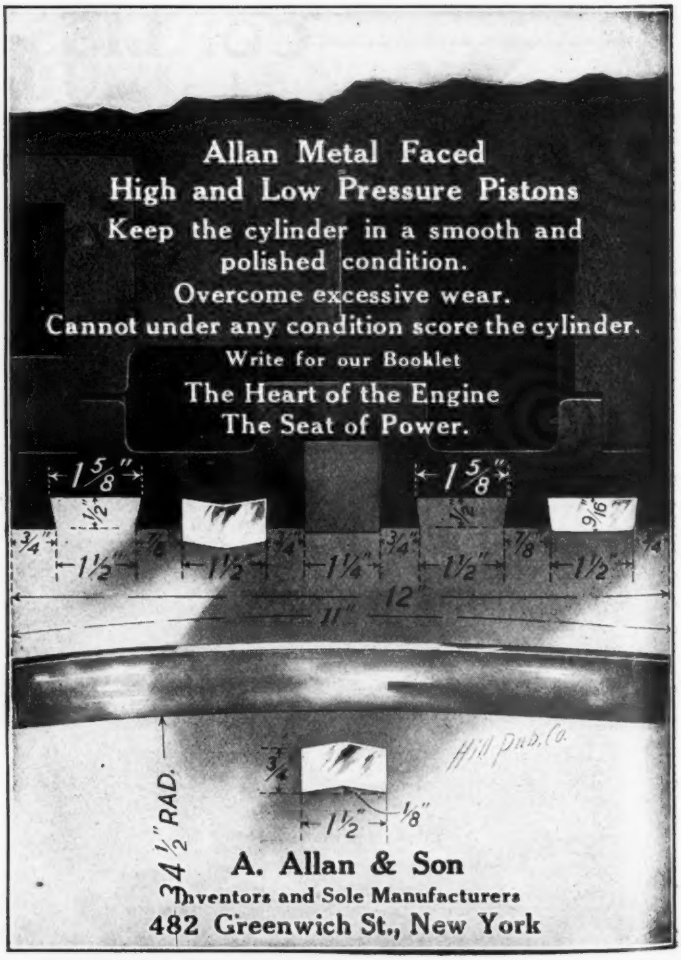
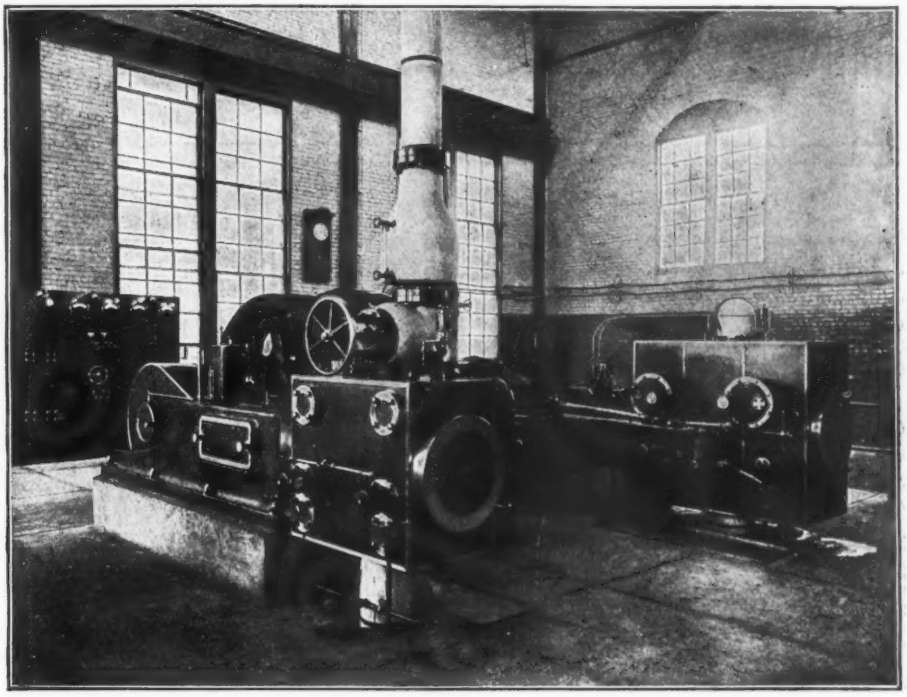


THE BALL ENGINE CO., ERIE, PA.



Cross Compound Non-Releasing Valve Gear Corliss Engine
Direct Connected to Generator, in Dean Electric Co. Plant, Elyria, Ohio.

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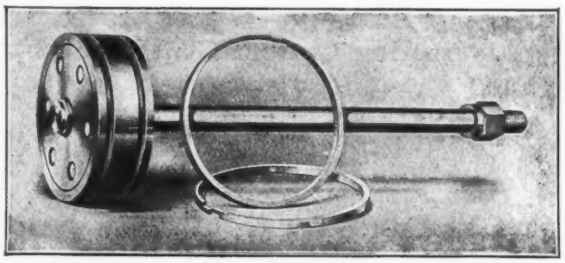
In Every Detail The Rollins Leads



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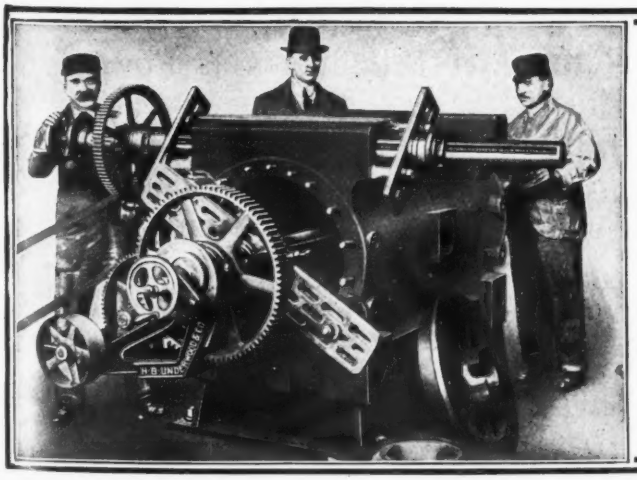
Pacific Coast Representatives—Armstrong-Kreling Machinery Co., San Francisco, Cal.



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will charge as much or more than we charge and we will save you the tearing down, trucking trouble and time that would be loss to your plant, if you sent the cylinder away.

Ammonia Cylinders Indicated.

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ESTABLISHED 1870

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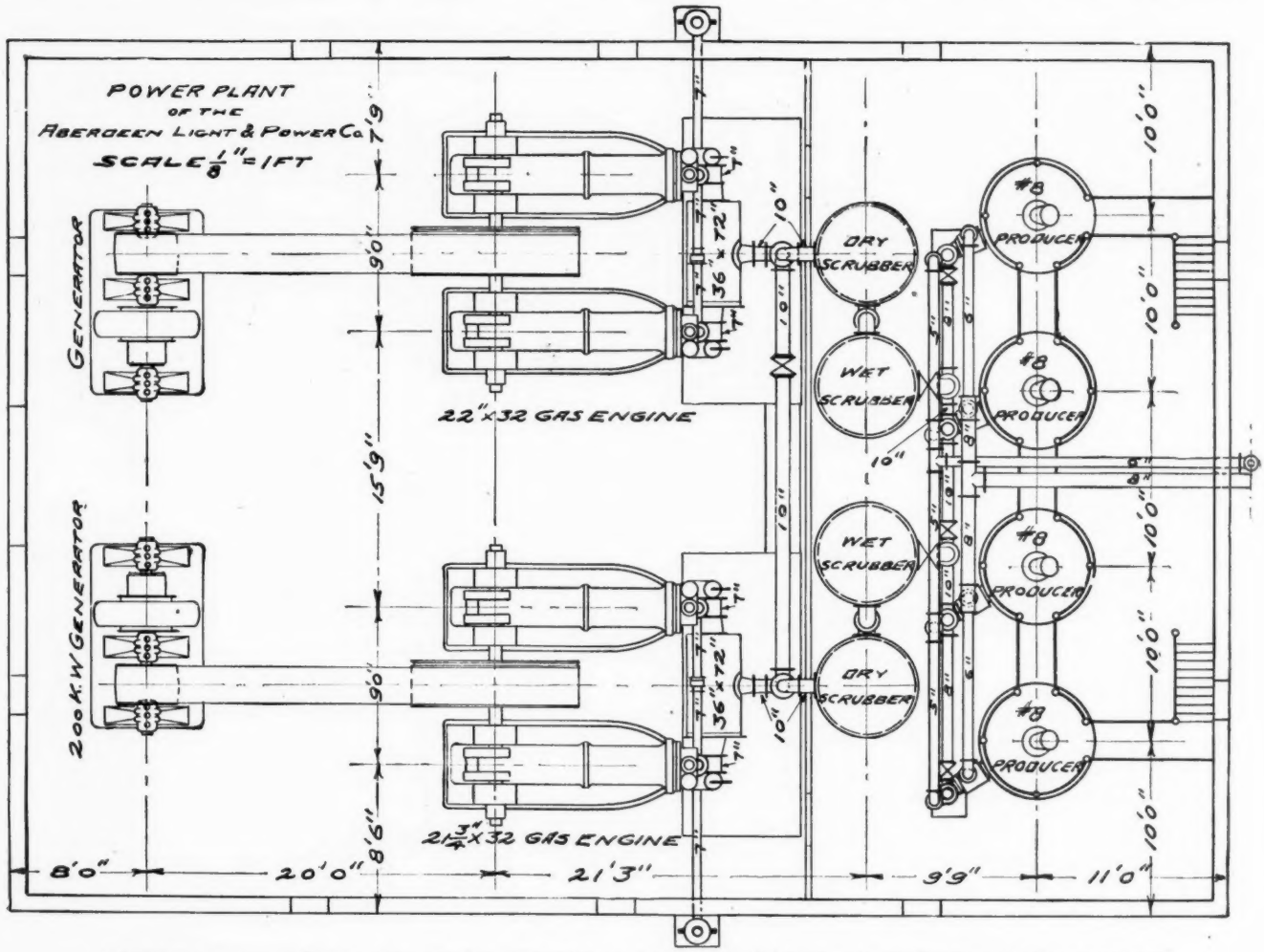

600 H.P. Muenzel Producer Gas Engines Driving Alternating Current Generators

The above is a plan of a municipal Electrical Power Plant showing Gas producers, wet and dry Gas Purifiers, Gas Engines and Electric Generators.

Suction Producers, operating on anthracite pea coal are employed. A considerable saving in floor space, the absence of a stack pouring out volumes of black smoke, and

A SAVING OF APPROXIMATELY 60% IN FUEL COST

are some of the many advantages of a **Muenzel** Producer Gas Power Plant over a steam plant.

We have been building Producer Gas Power Plants for the past four years and during this time have installed about eighty. Two of these have been destroyed by fire, the rest are in daily operation.

Not one of these plants has exceeded our guaranteed maximum coal consumption of 1 to 1¼ pounds of coal fed to the producer per Horse Power Hour delivered by the Engine at normal load.

We build these plants in sizes from 30 to 1500 H.P.

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A Yearly Oil Contract Commits Forgery Against Himself And Pays The Penalty Of Being Tied Up Twelve Months When He Might Be Free To Use

KEYSTONE GREASE

You'll see the folly of signing an oil contract as soon as you have given KEYSTONE GREASE a trial on your machinery.

KEYSTONE TRADE MARK REGISTERED U.S. PAT. OFF.

You'll find that "KEYSTONE" gives far better results, practically annihilating friction; requires only a fiftieth as much attention; does not melt and run away, or gum and clog up bearings; and outlasts the best oil 50 times over.

KEYSTONE GREASE is perfectly pure and it has a natural body, containing no talc, rosin, asbestos, graphite, acid, etc. It makes an actual power saving of from 25 to 75%. Think it over before the oil man gets you again.

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New York City Office, 96 Warren Street.
Southern Office, 610 Chartres St., New Orleans, La.
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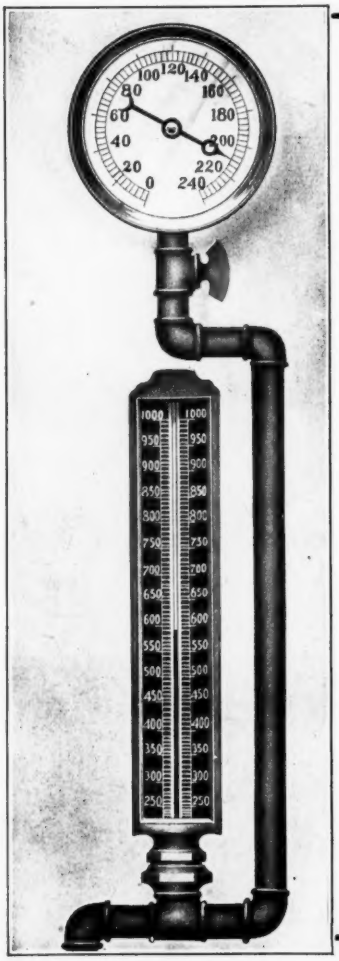

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the temperature of high pressure, super-heated steam.

You will see at once that no packing made of vegetable fibre, rubber, cotton, duck, flax, can stand the intense heat.

PALMETTO PACKING

is made of a mineral substance that heat cannot affect—perfect lubrication of each strand keeps it soft and pliable in service.

Palmetto is the packing for efficiency and long life under exacting conditions.

Send for FREE working samples and satisfy yourself.

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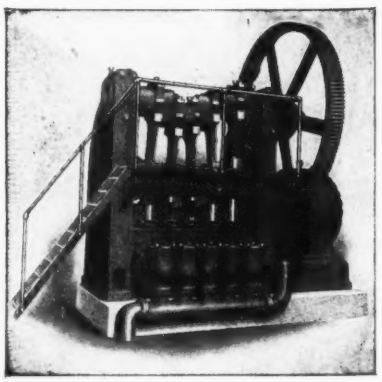
Westinghouse

Electric-Motor Drive

The comparison of power cost

between mechanical drive with shafting and belting and individual-motor drive, while varying with the conditions, varies only as to the degree of saving effected by individual-motor drive. The more complicated the transmission system, the greater the saving. With individual drive, shafting and belting need not be considered, simply wires. You can run wires anywhere.



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